SOLOMON RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body/Assessment Unit: Waconda Lake Basin including the Lower North Fork Solomon River, Lower South Fork Solomon River, Oak Creek, Kill Creek (Bloomington), Covert Creek, Twin Creek, Carr Creek, Beaver Creek (Gaylord), and Deer Creek (Kirwin)
Water Quality Impairment: Selenium

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower North Fork Solomon, Lower South Fork Solomon, Solomon River

Counties: Jewell, Mitchell, Norton, Osborne, Phillips, Rooks, and Smith

HUC 8: 10260012 **HUC 11** (14)**:** **010** (010, 020, 030, 040, 050, 060, 070) (Figure 1)
020 (010, 020, 030, 040, 050, 060, 070)
030 (010, 020, 030, 040, 050, 060, 070, 080, 090, 100)
040 (010, 020, 030, 040, 050, 060, 070, 080, 090)

10260014 **HUC 11** (14)**:** **010** (010, 020, 030, 040, 050, 060)
020 (010, 020, 030, 040, 050, 060, 070)
030 (010, 020, 030, 040, 050, 060, 070)
040 (010, 020, 030, 040, 050, 060)

10260015 **HUC 11** (14)**:** **010** (010, 020, 030)

Ecoregion: Central Great Plains, Rolling Plains and Breaks (27b)

Drainage Area: Approximately 2,490 square miles.

<u>Waconda Lake (Not Impaired)</u>

Conservation Pool: Area = 9,784 acres
Watershed Area: Lake Surface Area = 163:1
Maximum Depth = 14.0 meters (45.9 feet)
Mean Depth = 5.7 meters (19 feet)
Retention Time = 0.85 years (10 months)

Designated Uses: Primary and Secondary Contact Recreation; Expected Aquatic Life Support; Drinking Water; Food Procurement; Groundwater; Industrial Water Supply; Irrigation

Authority: Federal (U.S. Bureau of Reclamation) and State (Kansas Dept. of Wildlife and Parks)

Waconda Lake Basin

Main Stem Segment: WQLS: (5), 7, 9, 15, 21, & 22 (Lower North Fork Solomon River) and 3, 4, 5, 6, 7, 8, 9, 10, & 798 (Lower South Fork Solomon River) starting at Waconda Lake and traveling upstream to the Kirwin Lake dam and the Webster Lake dam.

Main Stem Segments with Tributaries by HUC 8 and Watershed/Station Number:

HUC 8: 10260012

Waconda Lake (018001)

Walnut Cr (26)
Granite Cr (24)
N. Fk. Solomon R (5)
S. Fk Solomon R (1)
S. Fk Solomon R (2)

Oak Creek (544)

Oak Cr (2)	Little Oak Cr (3)		
Oak Cr (4)	Buck Cr (43)		
	E. Oak Cr (40)		
	W. Oak Cr (39)		

Lower N Fork Solomon R. (14)

N.F. Solomon R (7)	Lindley Cr (45)		
	Lawrence Cr (44)		
	Dry Cr (42)		
	Spring Cr (8)		
N.F. Solomon R (9)			
N.F. Solomon R (15)	Cedar Cr (16)	East Cedar Cr (17)	
	Cedar Cr (18)	Middle Cedar Cr (19)	E. Middle Cedar Cr (37)
			W. Middle Cedar Cr (9019)
		West Cedar Cr (20)	
N.F. Solomon R (21)	Glen Rock Cr (41)		
	Medicine Cr (33)		
N.F. Solomon R (22)			

Beaver Creek (Gaylord) (670)

Beaver Cr (10)	E. Branch Beaver Cr (11)		
	Middle Beaver Cr (12)	W. Beaver Cr (14)	
	Middle Beaver Cr (13)		

Deer Creek (Kirwin) (721)

Deer Cr (23)	Plum Cr (24)
Deer Cr (25)	Big Cr (26)
Deer Cr (27)	Spring Cr (28)
Deer Cr (29)	Plotner Cr (30)
Deer Cr (31)	Broughton Cr (34)
	Starvation Cr (38)

HUC 8: 10260014

Carr Creek (669)

Carr Cr (21)

Twin Creek (668)

Twin Cr (20)	E. Twin Cr (29)

Lower S. Fk. Solomon River (542, 543)

S. Fk. Solomon R (3)	
S. Fk. Solomon R (4)	
S. Fk. Solomon R (5)	Medicine Cr (17)
S. Fk. Solomon R (6)	Crooked Cr (27)
	Lucky Cr (26)
	Medicine Cr (16)
S. Fk. Solomon R (7)	Jim Cr (25)
	Elm Cr (15)
S. Fk. Solomon R (8)	Robbers Roost Cr (24)
	Dibble Cr (363)
	Boxelder Cr (14)
S. Fk. Solomon R (9)	Cocklebur Cr (23)
	Ash Cr (22)
	Lost Cr (13)
S. Fk. Solomon R (10)	Sand Cr (395)
S. Fk. Solomon R (798)	

Covert Creek (666)

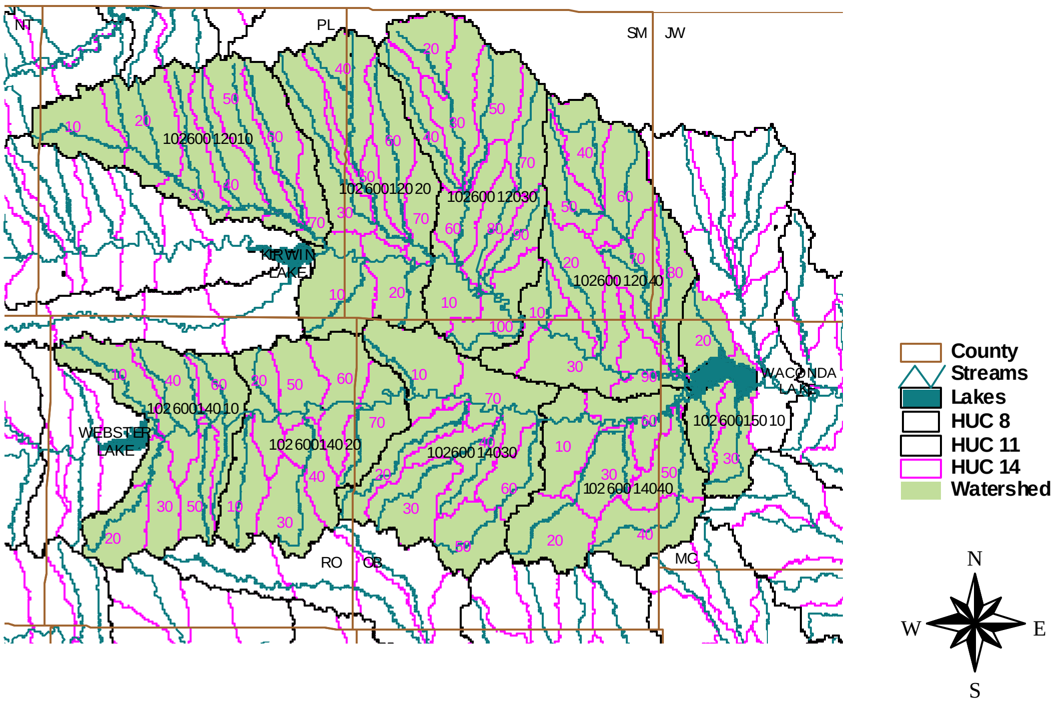
Covert Cr (19)

Kill Creek (Bloomington) (665)

Kill Cr (18)	E. Kill Cr (28)

Figure 1

Waconda Lake HUC 14



Designated Uses: Primary and Secondary Contact Recreation; Expected Aquatic Life Support; Drinking Water; Groundwater Recharge, Industrial Water Supply, Irrigation; Livestock Watering on Main Stem Segments

Food Procurement on all Main Stem Segments, except on segment 798 of the South Fork Solomon River

2002 303(d) Listing: Waconda Basin Streams

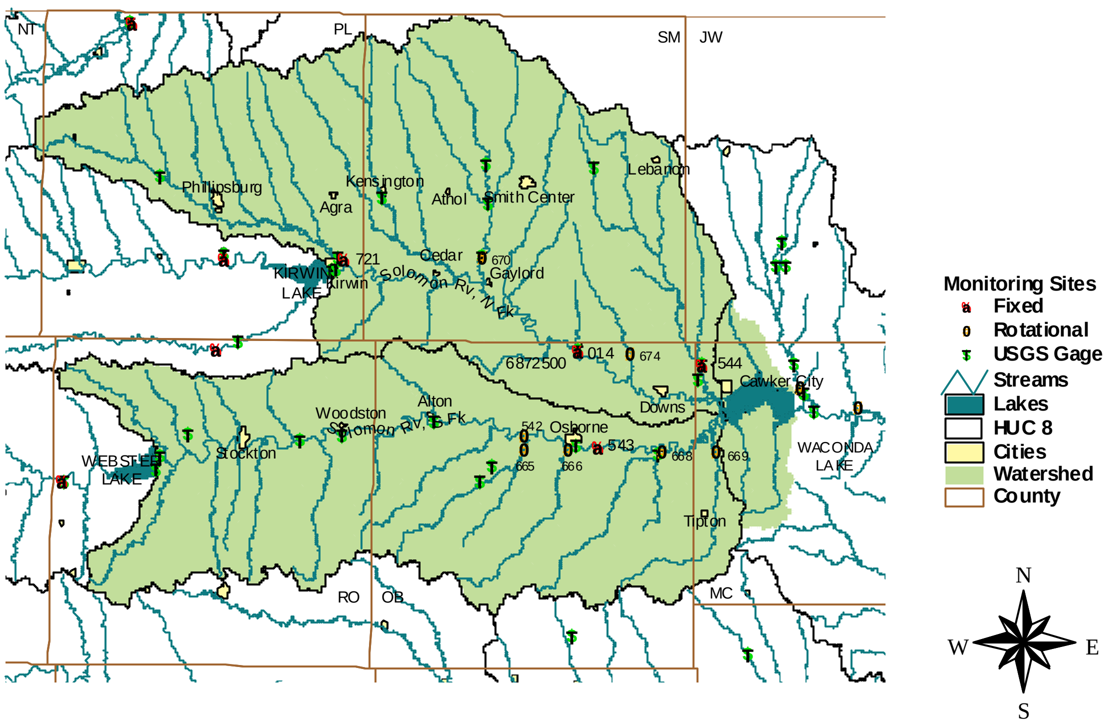
Impaired Use: Expected Aquatic Life Support

Water Quality Standard: 5 Fg/liter for Chronic Aquatic Life (KAR 28-16-28e(c)(2)(F)(ii)

In stream segments where background concentrations of naturally occurring substances, including chlorides and sulfates, exceed the water quality criteria listed in table 1a of subsection (d), at ambient flow, the existing water quality shall be maintained, and the newly established numeric criteria shall be the background concentration, as defined in K.A.R. 28-16-28b (e). Background concentrations shall be established using the methods outlined in the ''Kansas implementation procedures: surface water quality standards,'' as defined in K.A.R. 28-16-28b(ee), and available upon request from the department. (K.A.R.28-16-28e(b)(9))

Figure 2

Waconda Lake TMDL Reference Map



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2002 303(d): Not Supporting Expected Aquatic Life Support

Lake Monitoring Site: Station 018001 in Waconda Lake (Figure 2).

Period of Record Used: Six surveys during 1986 - 2001

Elevation Record: Waconda Lake at Glen Elder, KS (USGS Gage 06874200)

Stream Chemistry Monitoring Sites:

Monitoring and Flow Record Information for the Waconda Lake Basin

Monitoring Sites	Period of Record Used	Flow Record (USGS Gage)	Median Flows (cfs)
Station 014 at Portis (North Fork Solomon River)	1985 - 2002	North Fork Solomon River at Portis, KS (06872500)	34.7
Station 542 above Osborne (South Fork Solomon River)	1990 - 1998	South Fork Solomon River at Osborne, KS (06874000)	20.8
Station 543 below Osborne (South Fork Solomon River)	1990 - 2002	South Fork Solomon River at Osborne, KS (06874000)	20.8
Station 544 near Cawker City (Oak Creek)	1990 - 2001	Matched to flow duration for White Rock Cr nr Burr Oak (06853800)	8.0
Station 665 near Bloomington (Kill Creek)	1995 - 1999	Matched to flow duration for Salt C near Ada (06876700)	1.5
Station 666 near Osborne (Covert Creek)	1995 - 1999	Matched to flow duration for Salt C near Ada (06876700)	1.3
Station 668 near Corinth (Twin Creek)	1992 - 2000	Matched to flow duration for Salt C near Ada (06876700)	1.1
Station 669 near Cawker City (Carr Creek)	1992 - 2000	Matched to flow duration for White Rock Cr nr Burr Oak (06853800)	0.3
Station 670 near Gaylord (Beaver Creek)	1992 - 2000	Matched to flow duration for White Rock Cr nr Burr Oak (06853800)	7.1
Station 721 near Kirwin (Deer Creek)	1999 - 2001	Matched to flow duration for Bow Cr Nr Stockton (06871500)	5.3

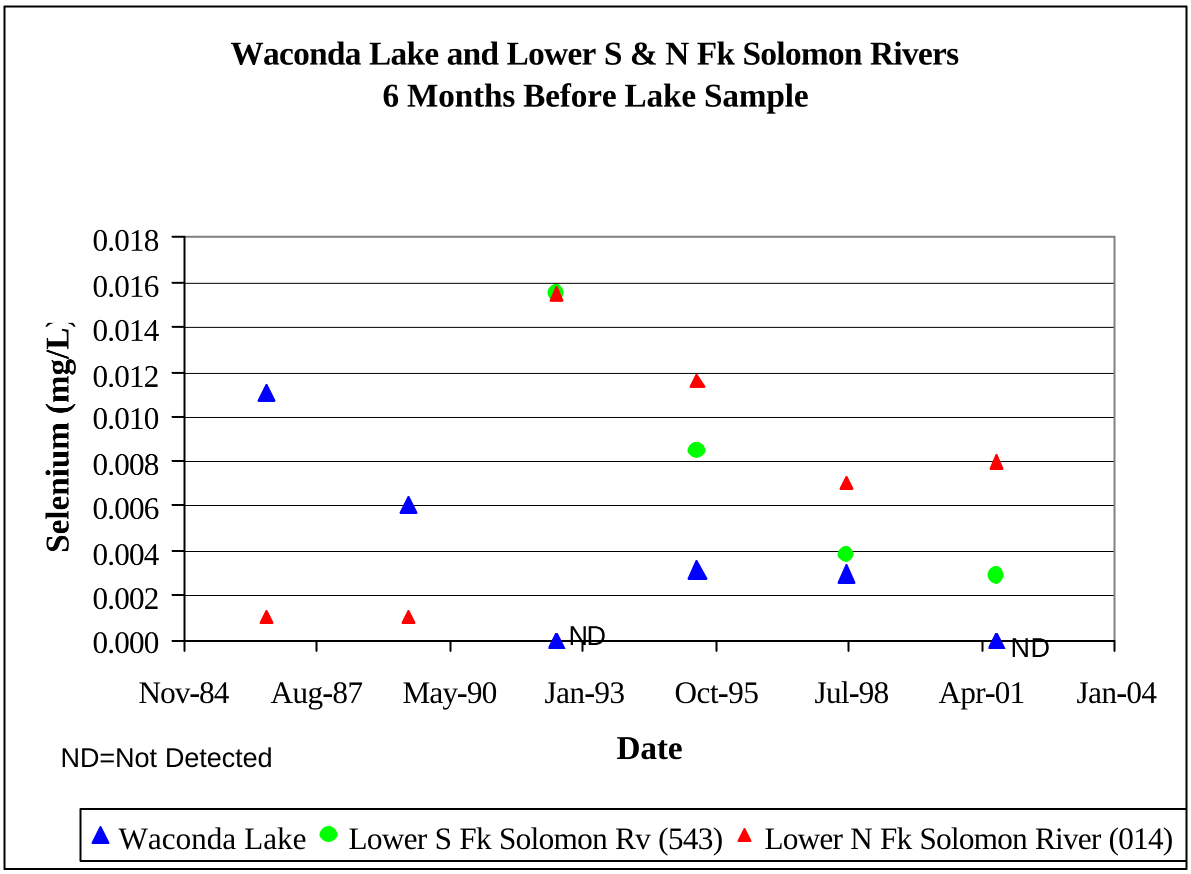
Current Condition: The selenium concentrations in Waconda Lake have been below the aquatic life support standard of 0.0050 mg/L since 1992 (Appendix A and table below). From 1986 through 1989, the average selenium concentration was 0.0085 mg/L. All the samples taken in 1992 and 2001 had selenium concentrations below the detection limit. The selenium concentration averaged 0.0031 mg/L for the sampling period between 1995 and 1998.

Average Selenium Concentrations in Waconda Lake

Date	Selenium (mg/L)	Elevation (feet)
7/28/86	0.0110	Active Pool = 1455.6
6/27/89	0.0060	1451.02
7/8/92	0.0300*	1454.17
6/6/95	0.0032	1466.84
7/14/98	0.0030	1456.14
8/7/01	0.0020*	1455.21

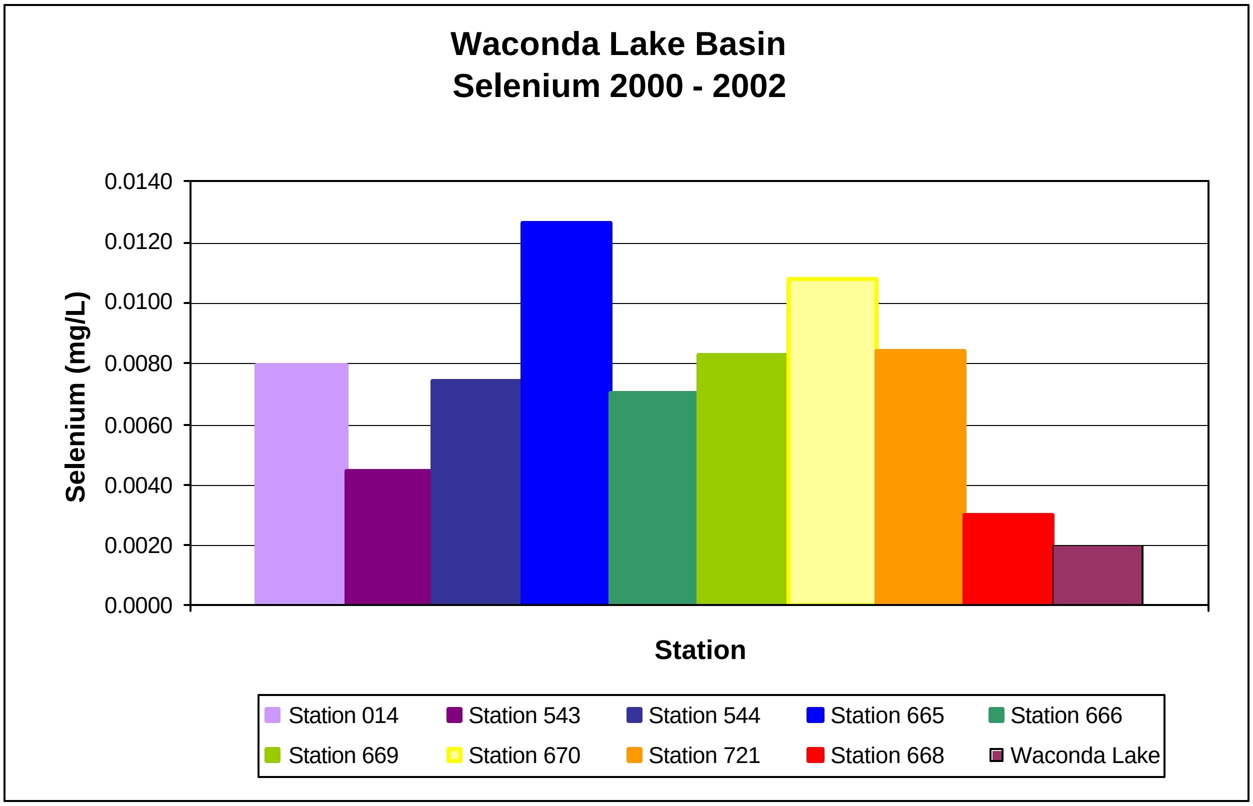
* The concentrations of the samples were below the detection limit. The detection limit is given in the table.

Figure 3



Since 1992, the selenium concentrations in the lake were consistently lower than the concentrations in the Lower and Upper South Fork Solomon Rivers (Figure 3). Over the 2000 to 2002 time period, the levels of selenium seen in the Upper South Fork Solomon River, stations 014 and 721, tend to be higher than those seen on the Lower South Fork Solomon River, station 543 (Figure 4 and Appendix A).

Figure 4



Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired loads over all flow conditions, rather than fixed at a single value. Sample data for the sampling sites were categorized for each of the three defined seasons: Spring (Apr-Jul), Summer-Fall (Aug-Oct) and Winter (Nov-Mar). High flows and runoff equate to lower flow durations; baseflow and point source influences generally occur in the 75-99% range. A load curve was established for the aquatic life support criterion by multiplying the flow values along the curve by the applicable water quality criterion and converting the units to derive a load duration curve of pounds of selenium per day. This load curves represent the TMDL since any point along the curve represents water quality for the standard at that flow. Historic excursions from the water quality standard are seen as plotted points above the load curve. Water quality standards are met for those points plotting below the load duration curve (Appendix B).

Station 014: Excursions were seen in each of the three defined seasons and are outlined below. Sixty-five percent of Spring samples and 73% of Summer-Fall samples were over the aquatic lifecriterion. Eighty-eight percent of Winter samples were over the criterion. Overall, 76% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 014 at Portis (North Fork Solomon River)	Spring	3	3	3	2	0	0	11/17=65%
	Summer	2	1	6	0	2	0	11/15=73%
	Winter	3	5	6	1	0	0	15/17=88%

Station 542: Excursions were seen in each of the three defined seasons and are outlined below. Fifty percent of Spring samples and 67% of Summer-Fall samples were over the aquatic lifecriterion. Fifty percent of Winter samples were over the criterion. Overall, 55% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 542 above Osborne (South Fork Solomon River)	Spring	2	0	0	0	0	0	2/4 = 50%
	Summer	0	0	2	0	0	0	2/3 = 67%
	Winter	2	0	0	0	0	0	2/4 = 50%

Station 543: Excursions were seen in each of the three defined seasons and are outlined below. Seventeen percent of Spring samples and 40% of Summer-Fall samples were over the aquatic lifecriterion. Forty-four percent of Winter samples were over the criterion. Overall, 33% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 543 below Osborne (South Fork Solomon River)	Spring	1	1	0	1	0	0	3/18 = 17%
	Summer	1	2	3	0	0	0	6/15 = 40%
	Winter	3	3	2	0	0	0	8/18 = 44%

Station 544: Excursions were seen in each of the three defined seasons and are outlined below. Seventy-three percent of Spring samples and 58% of Summer-Fall samples were over the aquatic lifecriterion. Seventy-five percent of Winter samples were over the criterion. Overall, 70% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 544 near Cawker City (Oak Creek)	Spring	2	4	5	0	0	0	11/15 = 73%
	Summer	0	0	1	6	0	0	7/12 = 58%
	Winter	1	3	6	2	0	0	12/16 = 75%

Station 665: Excursions were seen in each of the three defined seasons and are outlined below. Twenty-five percent of Spring samples and 33% of Summer-Fall samples were over the aquatic lifecriterion. Twenty-five percent of Winter samples were over the criterion. Overall, 27% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 665 near Bloomington (Kill Creek)	Spring	0	0	1	0	0	0	1/4 = 25%
	Summer	0	0	1	0	0	0	1/3 = 33%
	Winter	0	0	1	0	0	0	1/4 = 25%

Station 666: Excursions were seen in each of the three defined seasons and are outlined below. Twenty-five percent of Spring samples and 67% of Summer-Fall samples were over the aquatic lifecriterion. Twenty-five percent of Winter samples were over the criterion. Overall, 36% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 666 near Osborne (Covert Creek)	Spring	0	0	1	0	0	0	1/4 = 25%
	Summer	0	0	1	1	0	0	2/3 = 67%
	Winter	0	0	1	0	0	0	1/4 = 25%

Station 668: Excursions were seen in each of the three defined seasons and are outlined below. Forty percent of Spring samples and 100% of Summer-Fall samples were over the aquatic lifecriterion. One hundred percent of Winter samples were over the criterion. Overall, 70% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 668 near Corinth (Twin Creek)	Spring	1	0	0	1	0	0	2/5 = 40%
	Summer	0	0	0	1	0	0	1/1 = 100%
	Winter	1	0	2	0	1	0	4/4 = 100%

Station 669: Excursions were seen in each of the three defined seasons and are outlined below. Fifty percent of Spring samples and 100% of Summer-Fall samples were over the aquatic lifecriterion. None of the Winter samples were over the criterion. Overall, 38% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER SULFATE STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 669 near Cawker City (Carr Creek)	Spring	0	0	0	0	2	0	2/4 = 50%
	Summer	0	0	0	1	0	0	1/1 = 100%
	Winter	0	0	0	0	0	0	0/3 = 0%

Station 670: Excursions were seen in each of the three defined seasons and are outlined below. One hundred percent of Spring samples and 50% of Summer-Fall samples were over the aquatic lifecriterion. Seventy-five percent of Winter samples were over the criterion. Overall, 70% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 670 near Gaylord (Beaver Creek)	Spring	1	0	1	0	1	0	3/3 = 100%
	Summer	0	0	0	1	0	0	1/2 = 50%
	Winter	1	0	2	0	0	0	3/4 = 75%

Station 721: Excursions were seen in each of the three defined seasons and are outlined below. Fifty percent of Spring samples and 50% of Summer-Fall samples were over the aquatic life criterion. Eighty-six percent of Winter samples were over the criterion. Overall, 64% of the samples were over the criteria. This would represent a potential baseline condition of non-support of the impaired designated use.

NUMBER OF SAMPLES OVER Selenium STANDARD OF 5 ug/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Station 721 near Kirwin (Deer Creek)	Spring	0	1	0	1	0	0	2/4 = 50%
	Summer	0	0	1	0	0	1	2/4 = 50%
	Winter	0	1	3	1	0	0	5/6 = 83%

Additionally, data collected by the Bureau of Reclamation for its Environmental Assessment of Irrigation Service Contract from the Kirwin and Webster projects indicate elevated levels of selenium along the North and South Forks of the Solomon. Biological data also indicate a degree of bio-accumulation of selenium through the food chain. The Bureau continues to study and evaluate potential selenium problems and has employed an adaptive management approach to project irrigation. Stronger control on irrigation practices will commence if impairment issues arise from the current selenium levels.

Interim Endpoints of Water Quality (Implied Load Capacity) at Stations 014, 542, 543, 544, 665, 666, 668, 669, 670, and 721 over 2008 - 2012:

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting the chronic aquatic life support use. This TMDL will, however, be phased. The current standard of 0.005 mg/L of selenium was used to establish the TMDL. However, the Waconda Lake Watershed is subject to loading of selenium from the underlying upper Cretaceous bedrock and its high selenium content. As such, the watershed's streams often have elevated selenium levels from this natural source. To varying degrees, some of this elevated selenium is tied to historic water consumption via surface water irrigation. The background of selenium, consistently above 0.005 mg/L, makes achievement of the Standard unlikely under all flow conditions at Stations 544, 665, 666, 668, 669, 670, and 721. While irrigation impacts are noted along the North Fork Solomon River (Station 014), the frequency of exceedance of the 0.005 mg/l criterion occurs throughout the hydrologic spectrum, even very high flows which would mask the influence of irrigation. This would tend to implicate natural contributions along the North Fork. Nonetheless, the endpoint for Station 014 will remain 0.005 mg/l because of the potential impact of irrigation water use. Further data should be collected and analyzed for Station 014 in the future to reevaluate the applicability of a natural background concentration for selenium on the North Fork Solomon.

Irrigation impacts on the tributaries to the North and South Forks are scant, therefore, natural contributions are most likely and background concentrations will be calculated. On the other hand, the average selenium concentrations on the South Fork of the Solomon at Stations 542 and 543 for flows greater and less than the median are not significantly different from the Phase One endpoint, therefore, the 0.005 mg/l endpoint will apply to all flows at Stations 542, and 543. Likewise, the background concentration of Waconda Lake is not significantly different than the water quality standard, and thus the 0.005 mg/L endpoint will be used. At Stations 544, 665, 666, 668, 669, 670, and 721, however, since the criteria are not achievable because of natural contributions to the selenium load, an alternative endpoint will be needed.

Kansas Implementation Procedures for Surface Water allow for a numerical criterion based on natural background to be established from samples taken at flows less than median in-stream flow. Allowance is made under the Procedures for alternative calculations if concentrations are not proportional to flow. Since the elevation of selenium is particularly noteworthy at high flows, this alternative approach is required. The specific stream criteria to supplant the general standard will be developed concurrent with Phase One of this TMDL following the appropriate administrative and technical Water Quality Standards processes.

Meanwhile, tentative endpoints have been developed from currently available information at water quality monitoring stations 544, 665, 666, 668, 669, 670, and 721. Because of exceedances at variable flows, the background concentrations were taken as the average of samples collected at flow conditions bracketing the incidence of exceedance. In many cases, these averages included samples which were below the 0.005 mg/l criterion.

Background Concentrations in Waconda Lake Watershed

Station	Median Flow (cfs)	Background (mg/L)
Station 544 near Cawker City (Oak Creek)	8.0	0.012
Station 665 near Bloomington (Kill Creek)	1.5	0.009
Station 666 near Osborne (Covert Creek)	1.3	0.006
Station 668 near Corinth (Twin Creek)	1.1	0.012
Station 669 near Cawker City (Carr Creek)	0.3	0.008
Station 670 near Gaylord (Beaver Creek)	7.1	0.016
Station 721 near Kirwin (Deer Creek)	5.3	0.009

The Phase Two TMDL will be based on the future criteria applied to these contributing portions of the Waconda Lake Basin watershed at Stations 544, 665, 666, 668, 669, 670, and 721.

Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal consistency of elevated selenium levels. Achievement of the endpoints indicates loads are within the loading capacity of the stream, water quality standards are attained and full support of the designated uses of the stream has been restored.

3. SOURCE INVENTORY AND ASSESSMENT

Selenium Background: The main natural source of selenium in the Waconda Lake basin is from the weathering of upper Cretaceous bedrock that underlies the drainage basin. The upper Cretaceous bedrock, primarily the Niobrara Chalk, contains relatively high concentrations of selenium in comparison with other bedrock in Kansas. The bentonite beds and shales in the Chalk can be especially high in selenium. Soils weathered from the bedrock can have relatively high selenium content. Some plants growing in grasslands on soils containing high selenium concentration can accumulate enough selenium that they are toxic to livestock. Rainfall infiltrating through the high selenium soils and weathered bedrock leaches selenium. Water discharging from the soil and weathered bedrock transports dissolved selenium into streams. Evapotranspiration consumption of surface and ground water in the drainage basin then further increases the selenium concentration of the stream water.

Figure 5

Waconda Lake Geology

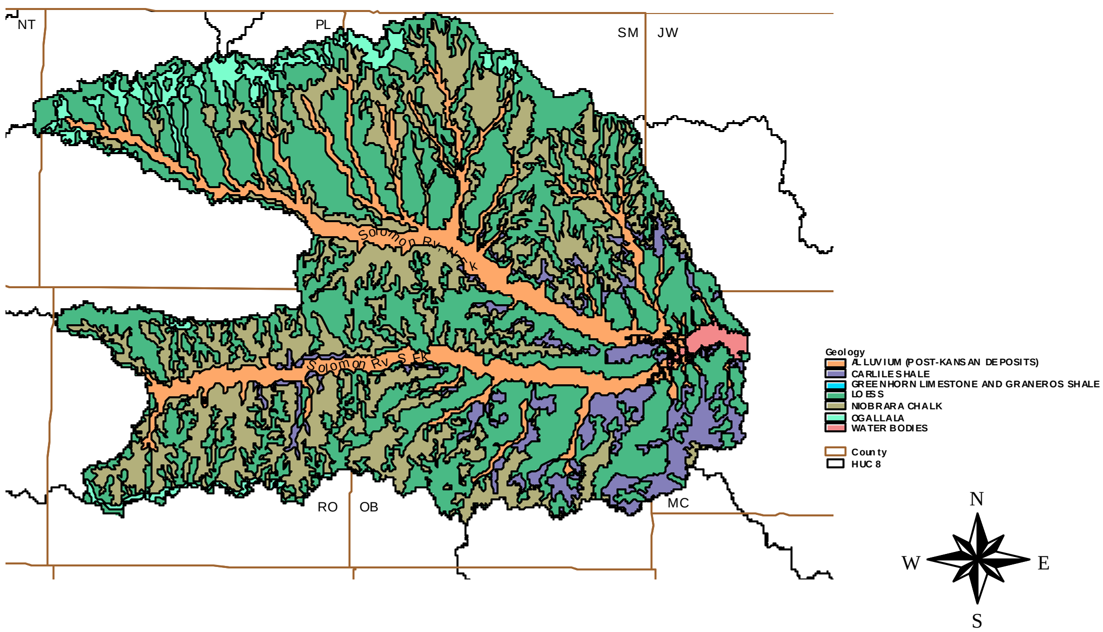
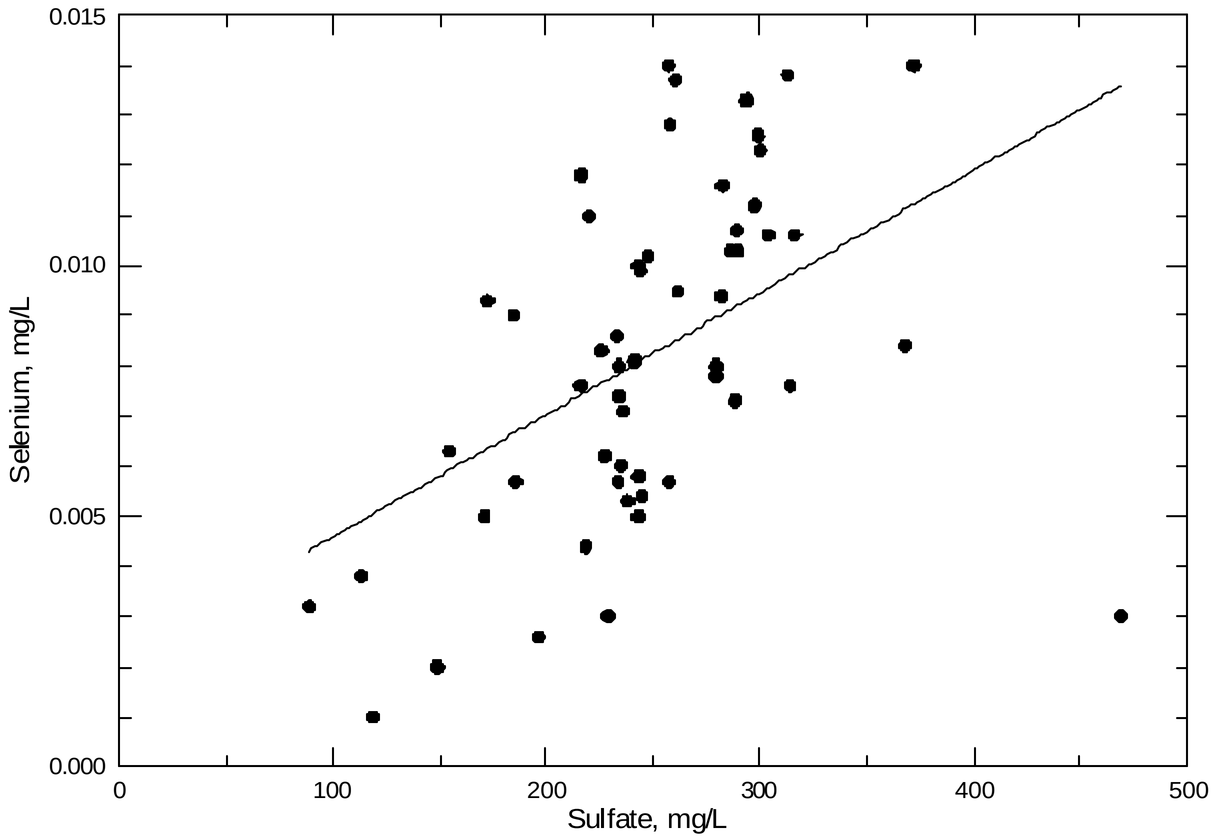


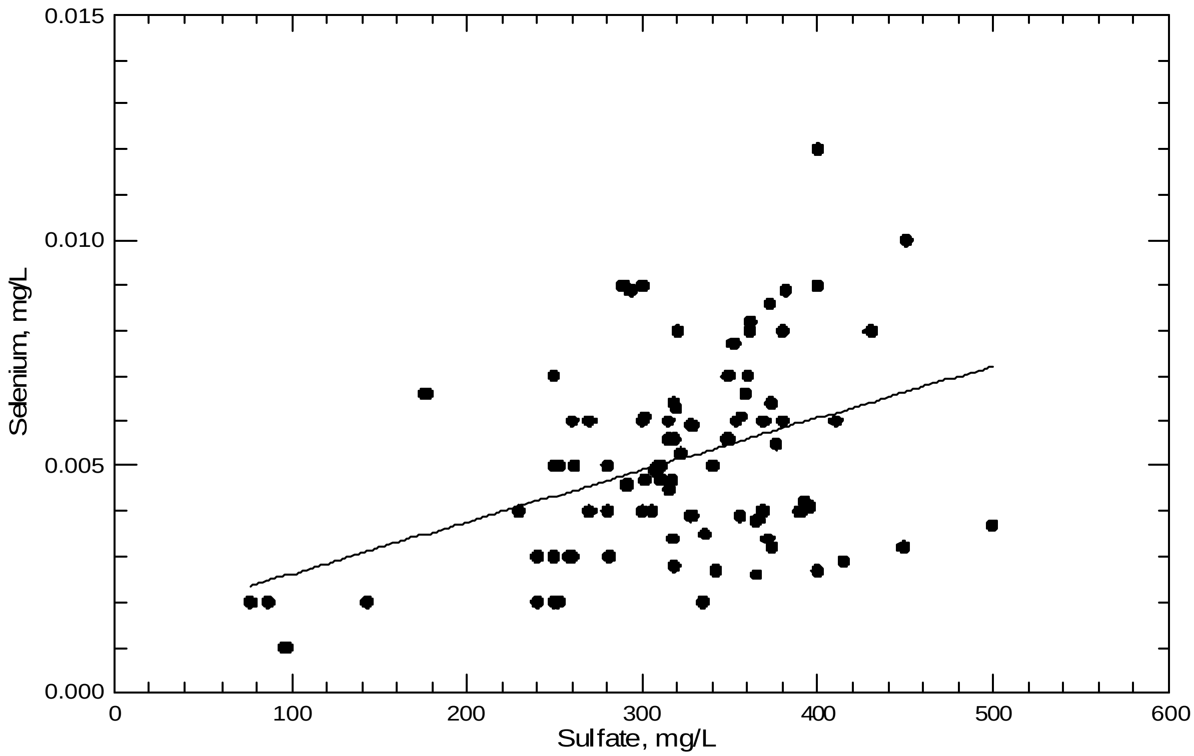
Figure 6. Selenium versus sulfate concentration for detectable levels of selenium in the lower North Fork Solomon River at Portis, station 014, during 1990 to early 2003.



Factors Controlling Variations in Selenium: The selenium concentrations range from <0.001 mg/L to 0.032 mg/L in the rivers and streams of the Lower North and South Solomon River basin. There is a general, statistically significant correlation of selenium content with total dissolved solids as well as with sulfate concentration for stations on the Lower North and South forks of the Solomon River (Figures 6 & 7). There is no apparent correlation of selenium levels with total dissolved solids and sulfate concentrations for individual stations for the tributaries. There is no substantial relationship between selenium content and flow at the river stations.

Long-term increases in the total dissolved solids and sulfate concentrations with time as a result of increased water consumption in the Solomon basin have probably also increased the selenium content of the streams and rivers in the basin. The main factor for the dissolved solids increase is the consumption of water by irrigation that leaves the residual dissolved salts, including selenium, in a smaller volume of water. Increases in selenium concentration of surface waters associated with irrigation and soils of high selenium content have been documented elsewhere in the United States (Jacobs, 1989). Nolan and Clark (1997) found that the presence or absence of Upper Cretaceous sediment and irrigation were the two most significant factors related to the selenium contents of surface and ground waters sampled as part of the National Irrigation Water Quality Program of the U.S. Department of the Interior. Phreatophytes in the riparian corridor of the rivers and tributaries in the Solomon basin have also increased the dissolved solids of shallow ground waters; concomitant increases in selenium contents in the shallow ground water discharged to streams would also be expected.

Figure 7. Selenium versus sulfate concentration for detectable levels of selenium in the lower South Fork Solomon River at or below Osborne, stations 015 (KDHE and USGS data for 1979-1994) and 543 (KDHE data for 1990 to mid 2003).



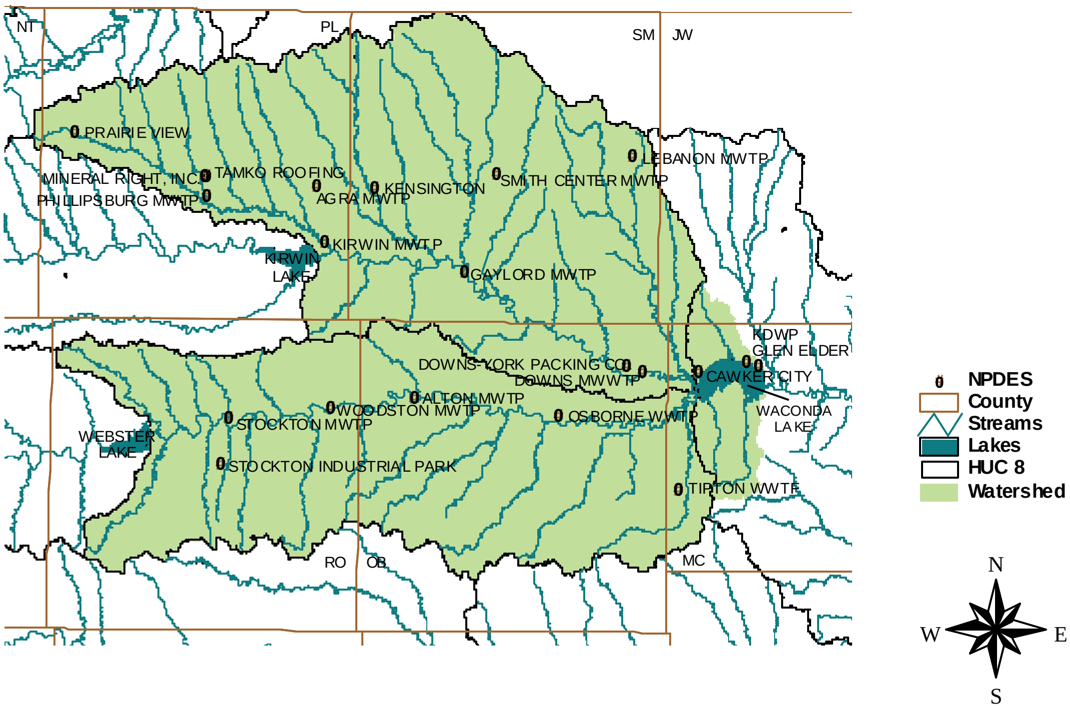
Irrigation Return Flows: Irrigation practices have probably increased the concentration of selenium from natural sources. Tailwater controls required by the state tend to limit the return flows from irrigated lands. Irrigation reports from 2001 show the following:

Water Use Statistics for Each Monitoring Site

Monitoring Sites	Surface Water		Groundwater	
	Area (acres)	Volume (acre-feet)	Area (acres)	Volume (acre-feet)
Station 014 at Portis (North Fork Solomon River)	1,054	800	4,551	3,345
Station 542 above Osborne (South Fork Solomon River)	207	15,197	2,411	1,432
Station 543 below Osborne (South Fork Solomon River)	360	15,311	2,513	1,485
Station 544 near Cawker City (Oak Creek)	90	65	78	83
Station 665 near Bloomington (Kill Creek)	N/A	N/A	N/A	N/A
Station 666 near Osborne (Covert Creek)	0	0	0	0
Station 668 near Corinth (Twin Creek)	0	0	0	0
Station 669 near Cawker City (Carr Creek)	0	0	0	0
Station 670 near Gaylord (Beaver Creek)	67	64	0	0
Station 721 near Kirwin (Deer Creek)	35	12	501	371

Figure 8

Waconda Lake NPDES Sites



NPDES: Twenty permitted waste treatment facilities are located within the watershed (Figure 8). Eleven are non-overflowing lagoons that are prohibited from discharging. The non-overflowing lagoons may contribute to the load under extreme precipitation events (flow durations exceeded under 5 percent of the time). Such events would not occur at a frequency or for a duration sufficient to cause an impairment in the watershed. Any anthropogenic selenium sources or hydrologic modifications increasing the selenium concentration would be minor in comparison with the selenium coming from natural sources.

Since none of the municipal NPDES sites in the watershed are currently required to monitor for selenium in their effluent, average selenium concentrations for municipal sources were estimated based on the selenium in their influent. For mechanical plants, a one to one ratio was used to estimate the selenium in effluent from the cities in the watershed's finished water. See Appendix C for the wasteload allocation calculations.

Waste Treatment Plants in the Waconda Lake Watershed

Kansas Permit Number	Name	Type	Design Capacity (MGD)	Se Wasteload Allocation
F-SO08-OO01	CAWKER CITY - WACONDA RES.	Three-cell lagoon	0.085	0.001 pounds/day
I-SO12-NP01	DOWNS-YORK PACKING CO.	six-cell lagoon	non-overflowing	0 pounds/day
I-SO31-PO01	TAMKO ROOFING PRODUCTS,INC.	aerated cells	monitor (average 0.027 in 2002)	0.004 pounds/day
I-SO41-NO02	STOCKTON INDUSTRIAL PARK	two wastewater systems	non-overflowing	0 pounds/day
M-SO01-NO01	AGRA MWTP	Three-cell lagoon	non-overflowing	0 pounds/day
M-SO02-NO01	ALTON MWTP	Three-cell lagoon	non-overflowing	0 pounds/day
M-SO12-OO01	DOWNS MWTP	Trickling Filter	0.15	0.010 pounds/day
M-SO15-NO02	GAYLORD MWTP	Three-cell lagoon	non-overflowing	0 pounds/day
M-SO18-NO02	KDWP - GLEN ELDER(EAST)	Three-cell lagoon	non-overflowing	0 pounds/day
M-SO18-NO03	KDWP - GLEN ELDER(WEST)	Two-cell Lagoon	non-overflowing	0 pounds/day
M-SO21-OO02	KENSINGTON	Three-cell lagoon	0.055	0.013 pounds/day
M-SO22-NO01	KIRWIN MWTP	Two-cell Lagoon	non-overflowing	0 pounds/day
M-SO23-NO01	LEBANON MWTP	Three-cell lagoon	non-overflowing	0 pounds/day
M-SO29-OO02	OSBORNE WWTP	Four-cell Lagoon	0.286	0.013 pounds/day
M-SO31-OO01	PHILLIPSBURG MWTP	Activated Sludge	0.35	0.052 pounds/day
M-SO33-NO01	PRAIRIE VIEW	Two-cell Lagoon	non-overflowing	0 pounds/day
M-SO38-IO01	SMITH CENTER MWTP	Activated Sludge	0.5	0.044 pounds/day
M-SO41-OO01	STOCKTON MWTP	Activated Sludge	0.275	0.007 pounds/day
M-SO42-OO01	TIPTON WWTF	Three-cell lagoon	0.023	0.001 pounds/day
M-SO43-NO01	WOODSTON MWTP	Three-cell lagoon	non-overflowing	0 pounds/day
		Total	**1.751**	**0.146 pounds/day**

Contributing Runoff: The watershed's average soil permeability is 1.3 inches/hour according to NRCS STATSGO database. About 90.5% of the watershed produces runoff even under relatively low (1.5''/hr) potential runoff conditions. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than soil permeabilities. As the watersheds' soil profiles become saturated, excess overland flow is produced. Generally, storms producing less than 0.5"/hr of rain will generate runoff from 4.6% of this watershed, chiefly along the stream channels.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

The source assessment has ascertained that natural selenium loading aggravated by irrigation practices within the watershed is overwhelmingly responsible for the excursions seen at the monitoring stations located within the Waconda Lake basin.

Point and Non-Point Sources: In the below table, under Phase One, the Wasteload and Load Allocations are given for all the stations included in this TMDL. The total Wasteload Allocation entering

Waconda Lake is 0.146 pounds per day. Under Phase Two, Load Allocations were calculated from the applicable background concentrations designated in the endpoint. Background concentrations were not determined for stations 542, 543, and the inflow into Waconda Lake, because the selenium concentrations are not significantly different from the Phase One endpoint.
Phase Two Wasteload Allocations were established based on the concentration of selenium assumed to be in each discharger's effluent, reflecting their source water content. No allowance was made for evaporation. Calculations for Wasteload Allocations are provided in Appendix C.

Allocations for Waconda Lake Watershed

Phase 1: 0.005 mg/L Endpoint											
	SC014	SC542	SC543	SC544	SC665	SC666	SC668	SC669	SC670	SC721	Inflow
Load Capacity (lbs/day)	0.9369	0.5616	0.5616	0.2160	0.0408	0.0350	0.0307	0.0080	0.1922	0.1431	29.0084
Wasteload Allocation (lbs/day)	0.0130	0.0073	0.0134	0.0*	0.0*	0.0*	0.0*	0.0012	0.0443	0.0557	0.0113
Load Allocation (lbs/day)	0.9239	0.5543	0.5482	0.2160	0.0408	0.0350	0.0307	0.0068	0.1480	0.0874	28.9971
Phase 2: Background Endpoints											
	SC014	SC542	SC543	SC544	SC665	SC666	SC668	SC669	SC670	SC721	Inflow
Background Concentration (mg/L)	Phase 1	Phase 1	Phase 1	0.012	0.009	0.006	0.012	0.008	0.016	0.009	Phase 1
Median Flow (cfs)	34.7	20.8	20.8	8.0	1.5	1.3	1.1	0.3	7.1	5.3	1074.3
Load Capacity (lbs/day)	Phase 1	Phase 1	Phase 1	0.5184	0.0729	0.0421	0.0713	0.0130	0.6134	0.2576	Phase 1
Wasteload Allocation (lbs/day)	Phase 1	Phase 1	Phase 1	0.0*	0.0*	0.0*	0.0*	0.0012	0.0443	0.0557	Phase 1
Load Allocation (lbs/day)	Phase 1	Phase 1	Phase 1	0.5184	0.0729	0.0421	0.0713	0.0142	0.6577	0.3133	Phase 1

* Should future point sources be proposed in the subwatershed and discharge into the impaired segments, the current wasteload allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers.

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of loading and the selenium endpoints for the Waconda Lake Watershed. The municipalities discharging to the Lower North and South Fork Solomon Rivers do not add selenium to their wastewaters, therefore, the selenium loads added by those facilities reflect the selenium content of their source water. Wasteload allocations were calculated based on source water concentrations without adjustment for evaporation in the treatment process.

The municipalities with the three highest levels of selenium in their source water; Kensington, Smith Center and Phillipsburg have evidence of marginal impact to the downstream site concentrations. Above Station 14, Kensington has too small a volume to alter either the existing or desired concentrations. On Beaver Creek, Smith Center shows no impairment under very low flow conditions and provides some dilution as flows from the surrounding watershed increase. On Deer Creek, Phillipsburg shows no impairment on the samples taken under the three lowest flow conditions.

Furthermore, the unlikelihood of the design flows of the individual point sources and resulting wasteloads reaching the monitoring stations because of transit losses of flow and diversion by intervening irrigation, along with the stagnant or declining population bases of the municipalities and the prevalence of exceedances at higher flows, where wasteload impacts are negligible, makes the Margin of Safety implicitly assure that the Wasteload Allocations will not cause an exceedance of the endpoints of this TMDL.

There are varying degrees of impact on selenium levels from historic irrigation within the drainage of Waconda Lake. In the long term, the Load Allocations established by this TMDL reflect either the existing water quality standard or the background concentrations. The Margin of Safety implicitly assures these Load Allocations will achieve the endpoints of the TMDL through policies and objectives established under the Kansas Water Plan. Two objectives under the State Water Plan call for, by 2010; 1) reduction of water level decline rates within the Ogallala aquifer and implementation of enhanced water management in targeted areas; and, 2) reduction in the number of irrigation points of diversion for which the amount of water applied in acre-feet per acre exceeds an amount considered reasonable for the area and those [irrigation points of diversion] that overpump the amount authorized by their water rights. Pursuit of these two water conservation objectives will have water quality benefits, including assuring excessive irrigation will not directly or indirectly load surface waters with residual salts, thereby causing endpoints to be non-attained.

State Water Plan Implementation Priority: Because the selenium impairment in Waconda Lake basin is primarily from natural geologic sources, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: Waconda Lake watershed lies within the Lower North Fork Solomon (HUC 8: 10260012) with a priority ranking of 34 (Medium Priority for restoration), Lower South Fork Solomon (HUC 8: 10260014) with a priority ranking of 45 (Medium Priority for restoration), and Solomon River (HUC 8: 10260015) with a priority ranking of 23 (High Priority for restoration).

Priority HUC 11s: Because of the natural geologic contribution of this impairment, targeting stream reaches overlying the Niobrara Chalk will be the focus of this TMDL.

5. IMPLEMENTATION

Desired Implementation Activities

1. Monitor any anthropogenic contributions of selenium loading to the lake and rivers.
2. Establish alternative background criteria.
3. Evaluate impacts of irrigation best management practices to abate salt loading.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. Municipal permits for facilities in the watershed will be renewed after 2004 with selenium monitoring and any appropriate permit limits, which protect the aquatic life criteria.

Watershed Management - KDHE

a. Evaluate any potential anthropogenic activities which might contribute selenium to the lake as part of an overall Watershed Restoration and Protection Strategy.

b. Evaluate impact of irrigation return flows on selenium loading to streams.

Watershed Planning - KDHE

a. Evaluate Bureau of Reclamation studies showing elevated selenium levels impairing stream biota and revise this TMDL accordingly.

Water Quality Standards and Assessment - KDHE

a. Establish background levels of selenium for the rivers and tributaries.

Subbasin Management - DWR

a. Evaluate Best Management Practices for irrigation which decrease salt loading to streams.

b. Coordinate Irrigation District Operations intended to reduce salt loadings.

Time Frame for Implementation: Development of a background level-based water quality standard should be accomplished with the next water quality standards revision.

Targeted Participants: Primary participants for implementation will be KDHE and DWR.

Milestone for 2008: The year 2008 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, additional monitoring data from the streams above Waconda Lake will be reexamined to confirm the impaired status of the watershed and the suggested background concentration. Should the case of impairment remain, source assessment, re-allocation and implementation activities will ensue.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment and Division of Water Resources.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

6. K.S.A. 82a-701, et seq. authorizes the Chief Engineer of the Division of Water Resources to condition the appropriation and use of water so as to not cause degradation of the water quality of Kansas streams and lakes.

7. The *Kansas Water Plan* and the Solomon Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Low Priority consideration and should not receive funding until irrigation best management practices demonstrate potential reductions in salt concentration.

Effectiveness: Minimal control can be exerted on the amount of natural background.

6. MONITORING

KDHE will continue to collect samples at Stations 014, 542, 543, 544, 665, 666, 668, 669, 670, and 721. Based on that sampling, the priority status will be evaluated in 2007 including development of numeric criteria based on background concentrations, as appropriate. Should impaired status remain, the desired endpoints under this TMDL will be refined and direct more intensive sampling will need to be conducted under specified seasonal flow conditions over the period 2008-2012.

Annual monitoring of selenium levels in effluent will be a condition of NPDES and state permits for facilities.

This monitoring will continually assess the functionality of the systems in reducing selenium levels in the effluent released to the streams upstream of Waconda Lake.

Studies by the Bureau of Reclamation will be incorporated in future versions of this TMDL if those studies indicate growing biological impairments tied to elevated selenium levels supported by this TMDL.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Solomon Basin were held January 7 and March 3, 2003 in Stockton. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Solomon Basin.

Public Hearing: A Public Hearing on the TMDLs of the Solomon Basin was held in Stockton on June 2, 2003.

Basin Advisory Committee: The Solomon Basin Advisory Committee met to discuss the TMDLs in the basin on October 3, 2002, January 7, March 3, and June 2, 2003.

Milestone Evaluation: In 2008, evaluation will be made as to the degree of impairment which has occurred within the watershed and current condition of Waconda Lake. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The lake will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2008-2012. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2004 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process after Fiscal Year 2008.

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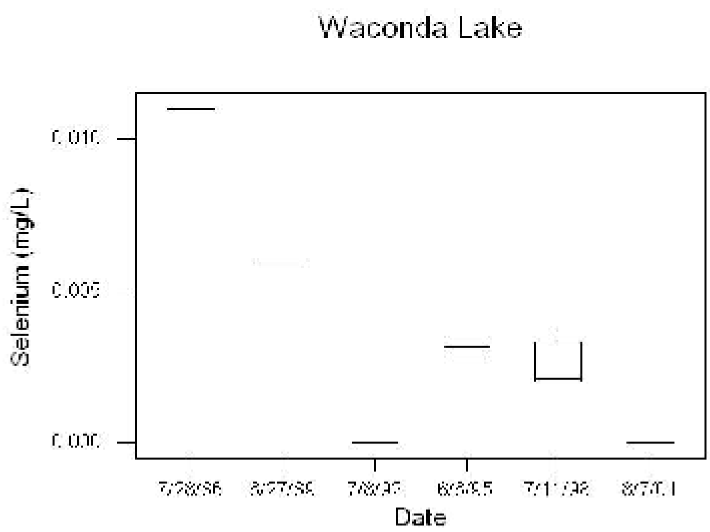
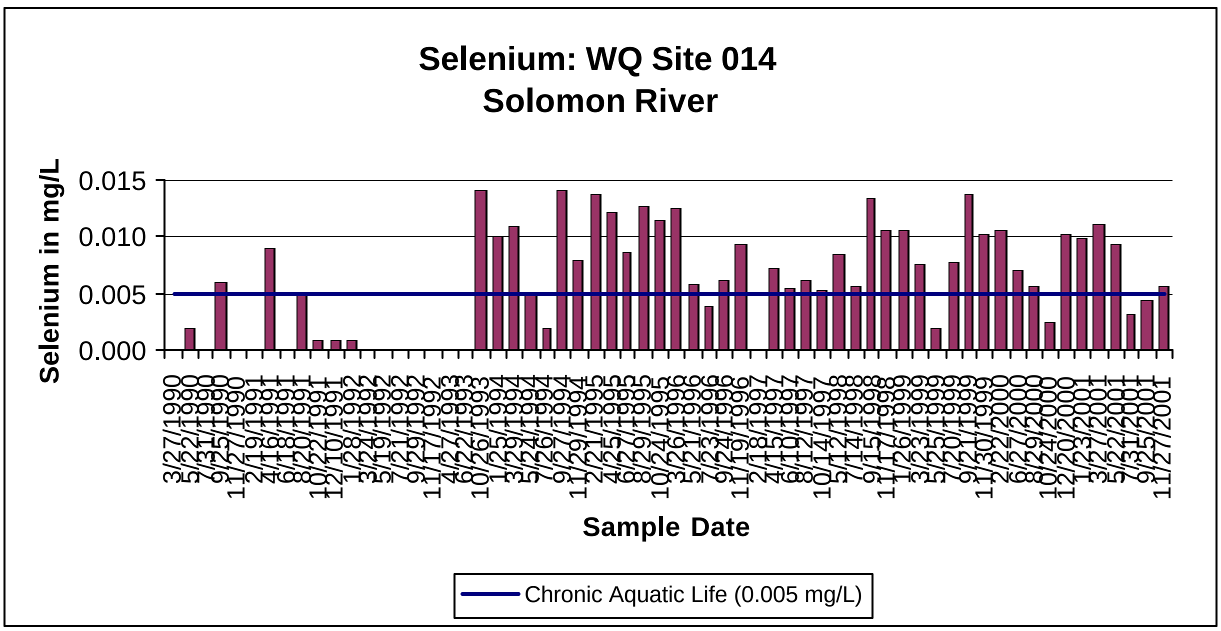
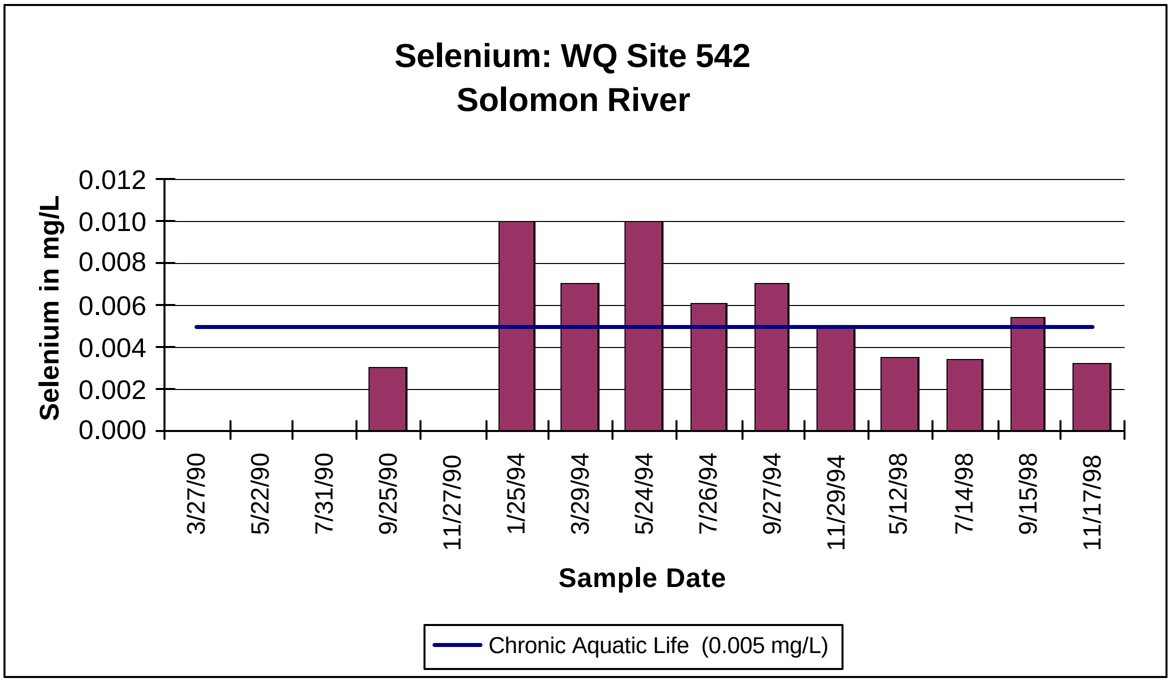
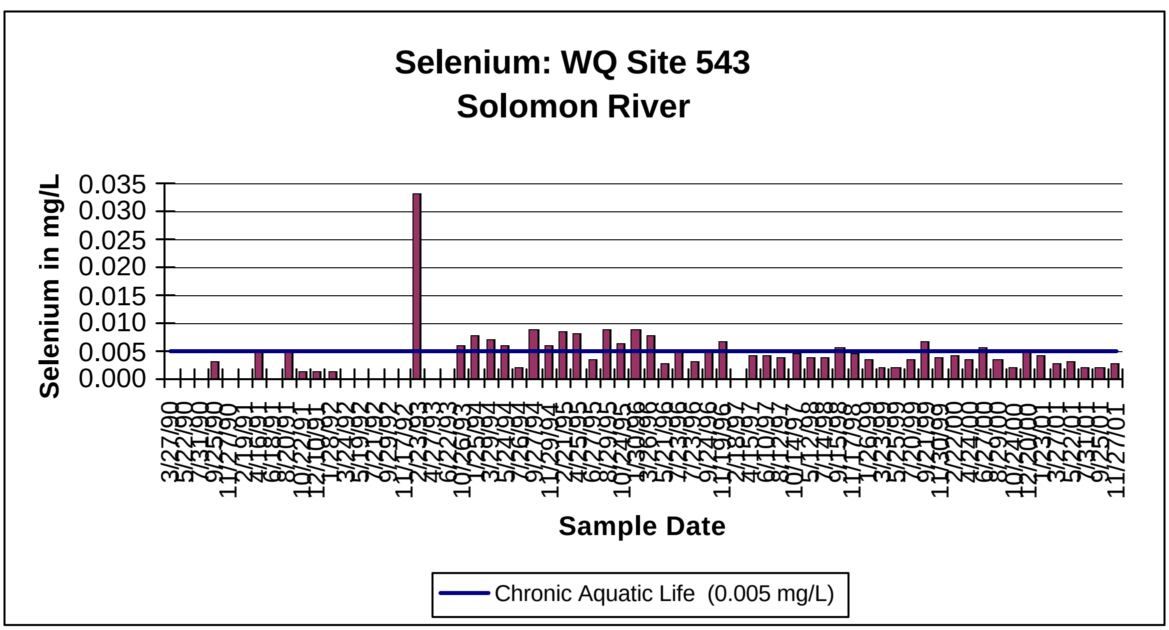
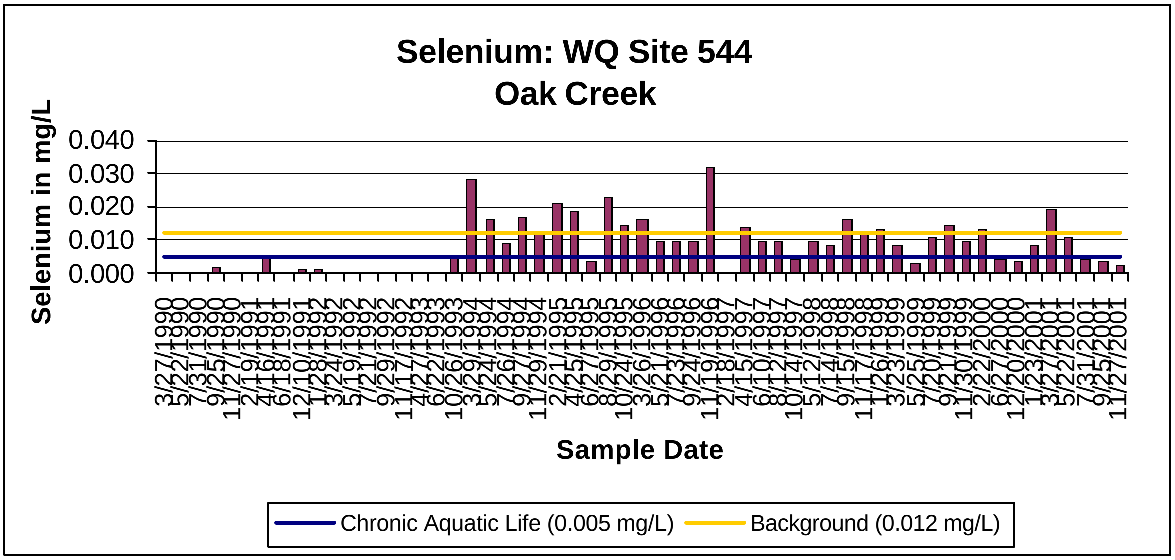
Appendix A - Boxplot and Concentration Graphs

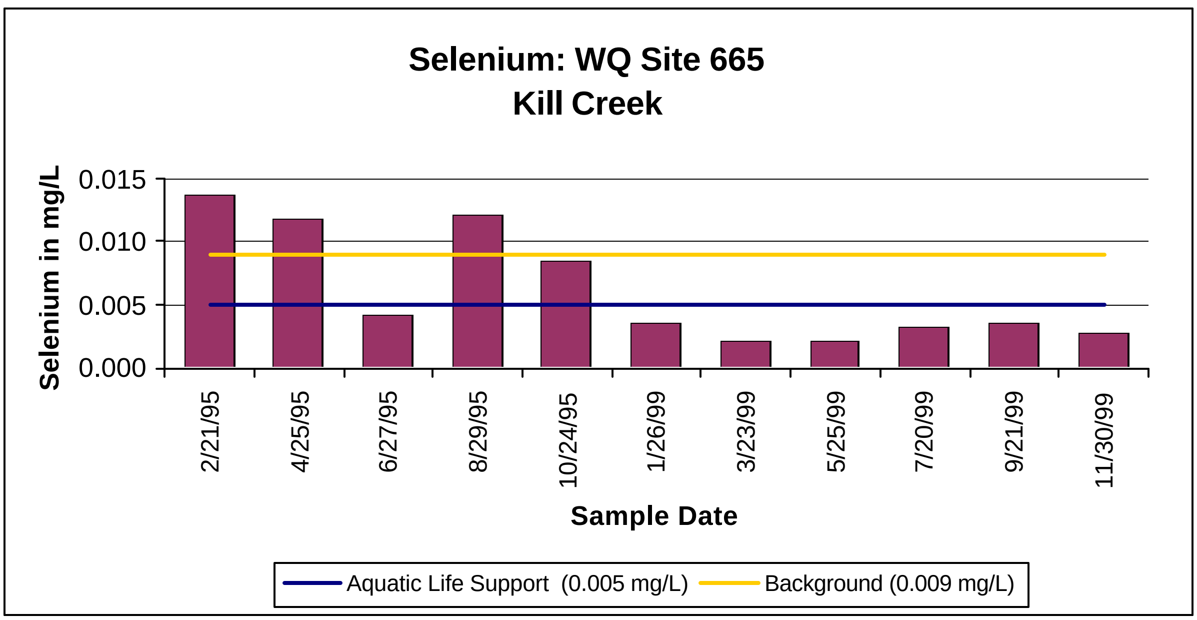


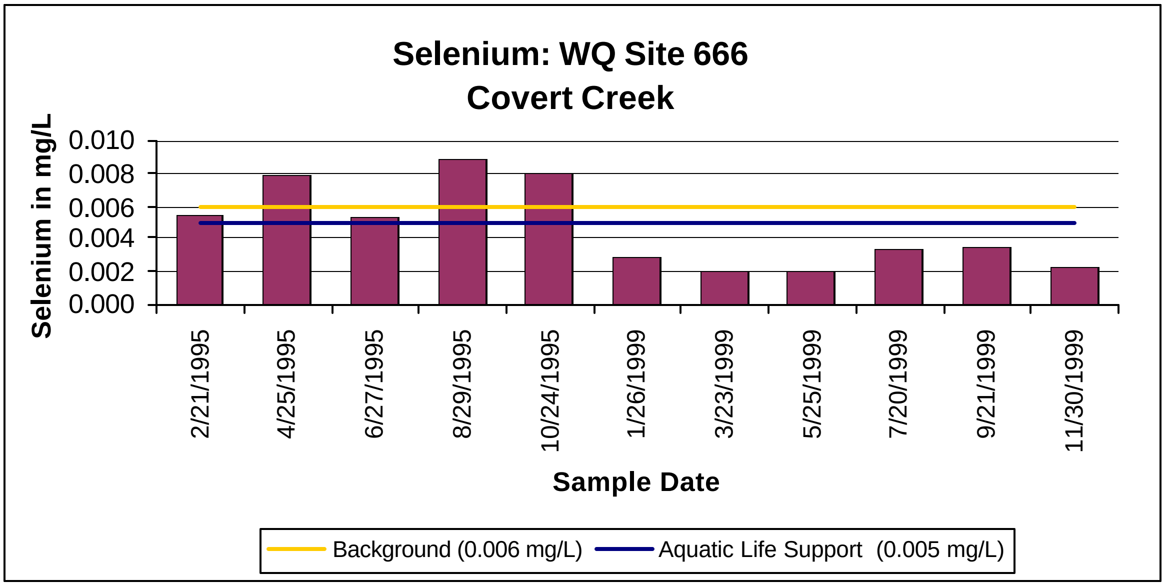


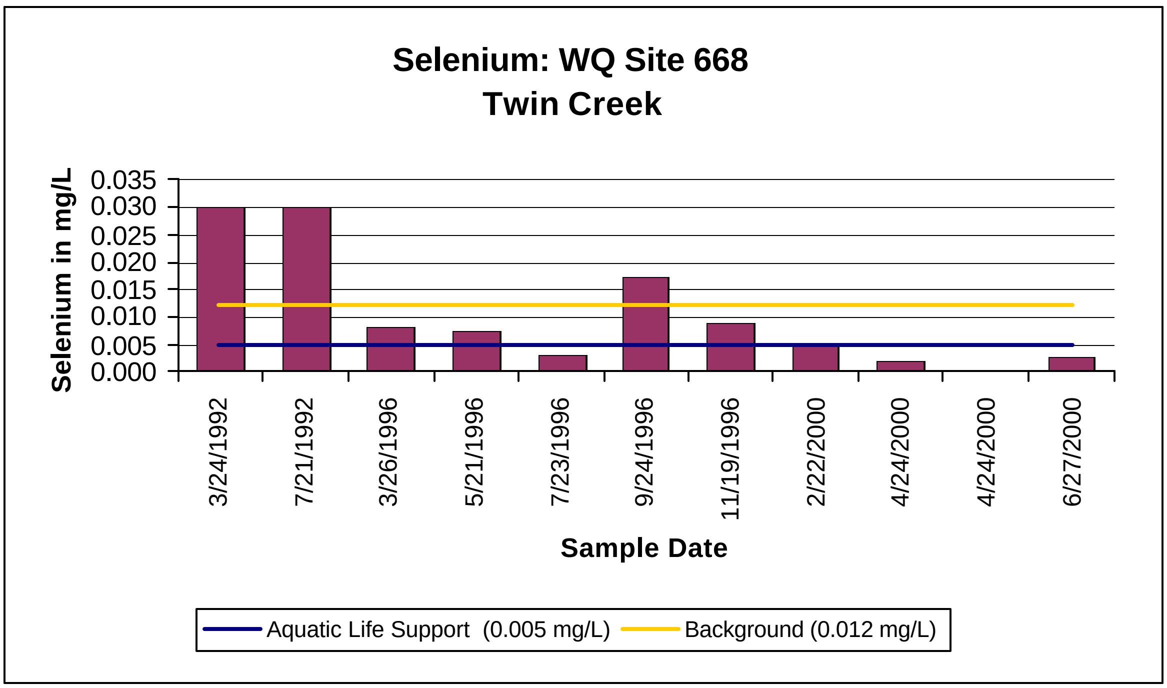

Selenium: WQ Site 542
Solomon River
Selenium in mg/L
0.012
0.010
0.008
0.006
0.004
0.002
0.000
3/27/90
5/22/90
7/31/90
9/25/90
11/27/90
1/25/94
3/29/94
5/24/94
7/26/94
9/27/94
11/29/94
5/12/98
7/14/98
9/15/98
11/17/98
Sample Date
Chronic Aquatic Life (0.005 mg/L)

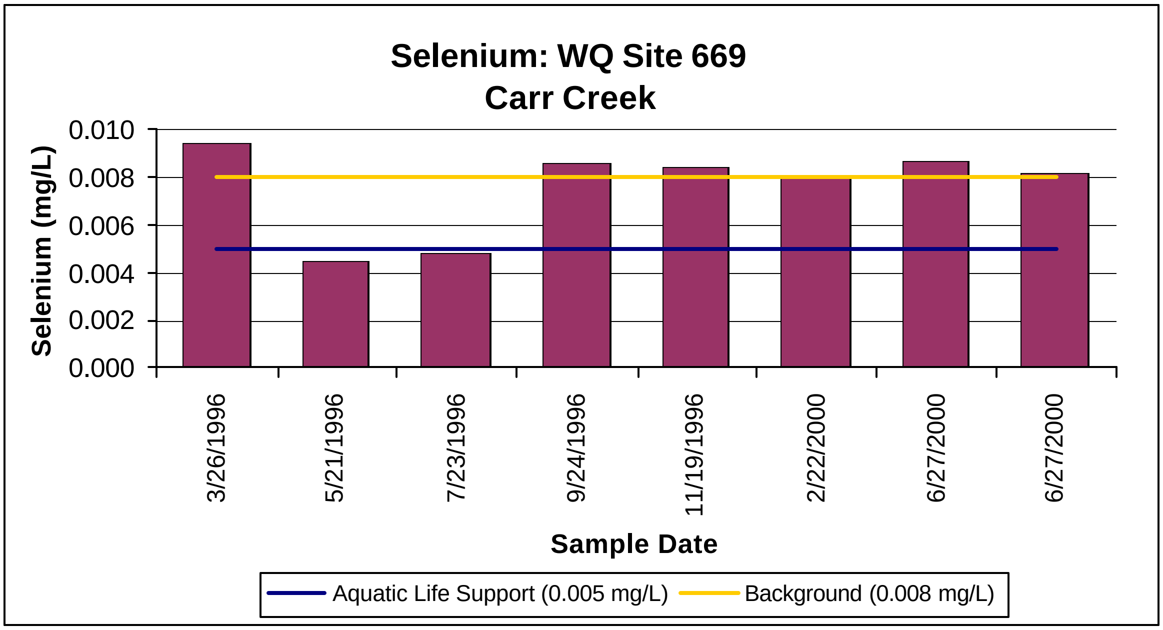

Selenium: WQ Site 543
Solomon River
Selenium in mg/L
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Sample Date
Chronic Aquatic Life (0.005 mg/L)

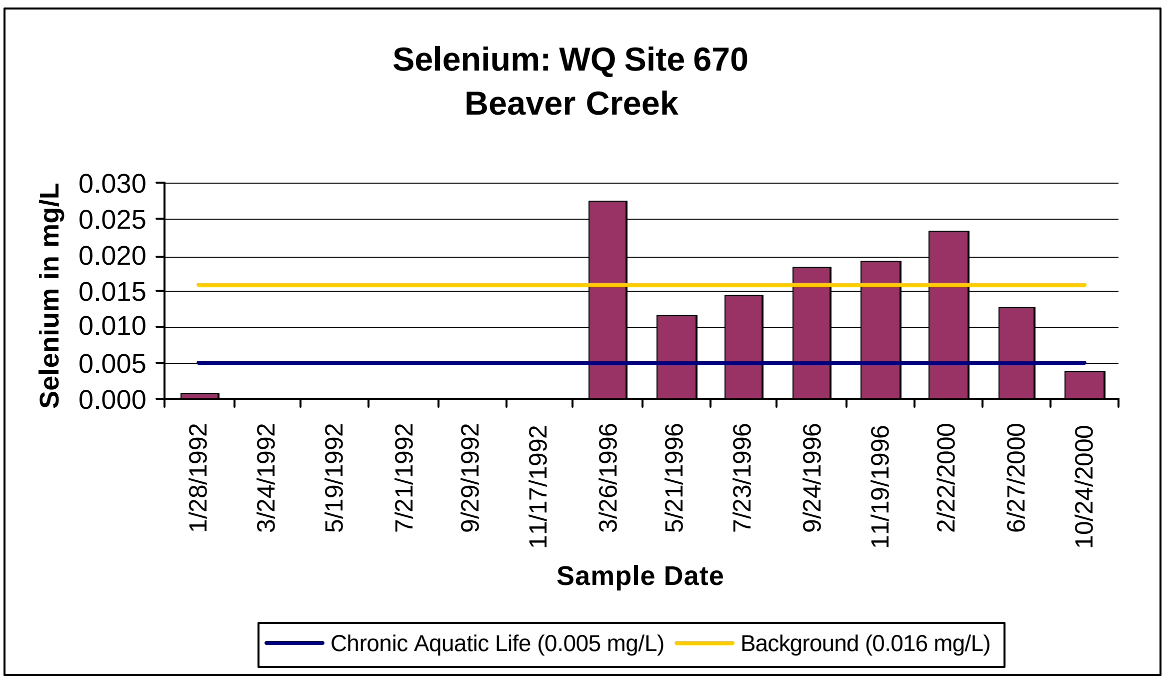

Selenium: WQ Site 544
Oak Creek
Selenium in mg/L
0.040
0.030
0.020
0.010
0.000
Sample Date
Chronic Aquatic Life (0.005 mg/L)
Background (0.012 mg/L)

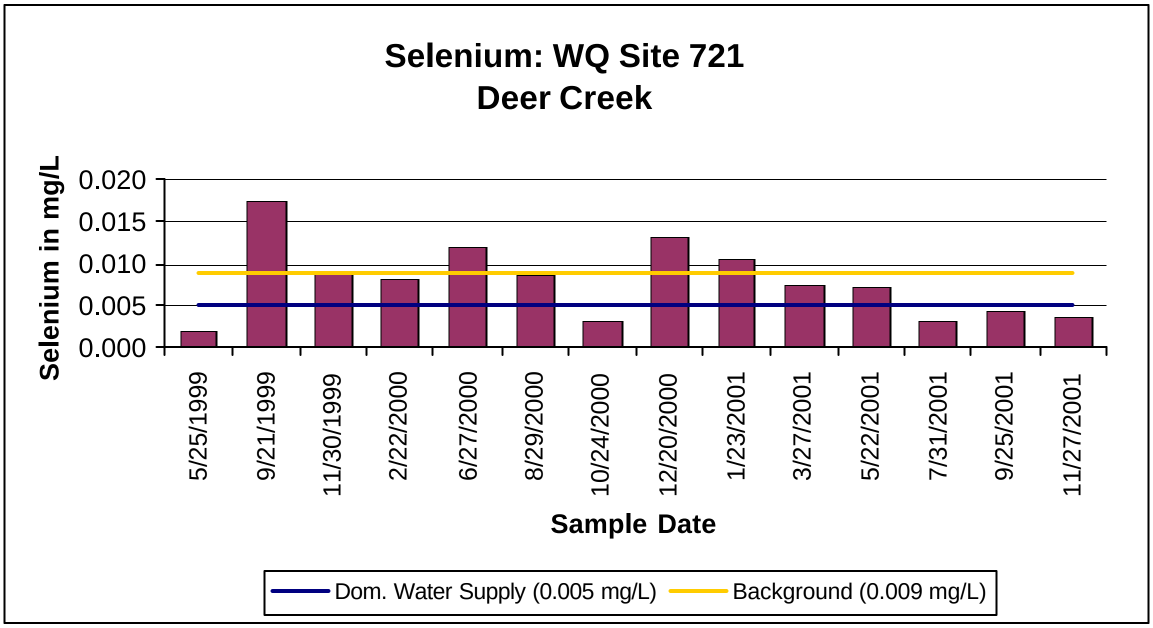

Selenium: WQ Site 665
Kill Creek
Selenium in mg/L
0.015
0.010
0.005
0.000
2/21/95
4/25/95
6/27/95
8/29/95
10/24/95
1/26/99
3/23/99
5/25/99
7/20/99
9/21/99
11/30/99
Sample Date
Aquatic Life Support (0.005 mg/L)
Background (0.009 mg/L)


Selenium: WQ Site 666
Covert Creek
Selenium in mg/L
0.010
0.008
0.006
0.004
0.002
0.000
2/21/1995
4/25/1995
6/27/1995
8/29/1995
10/24/1995
1/26/1999
3/23/1999
5/25/1999
7/20/1999
9/21/1999
11/30/1999
Sample Date
Background (0.006 mg/L)
Aquatic Life Support (0.005 mg/L)

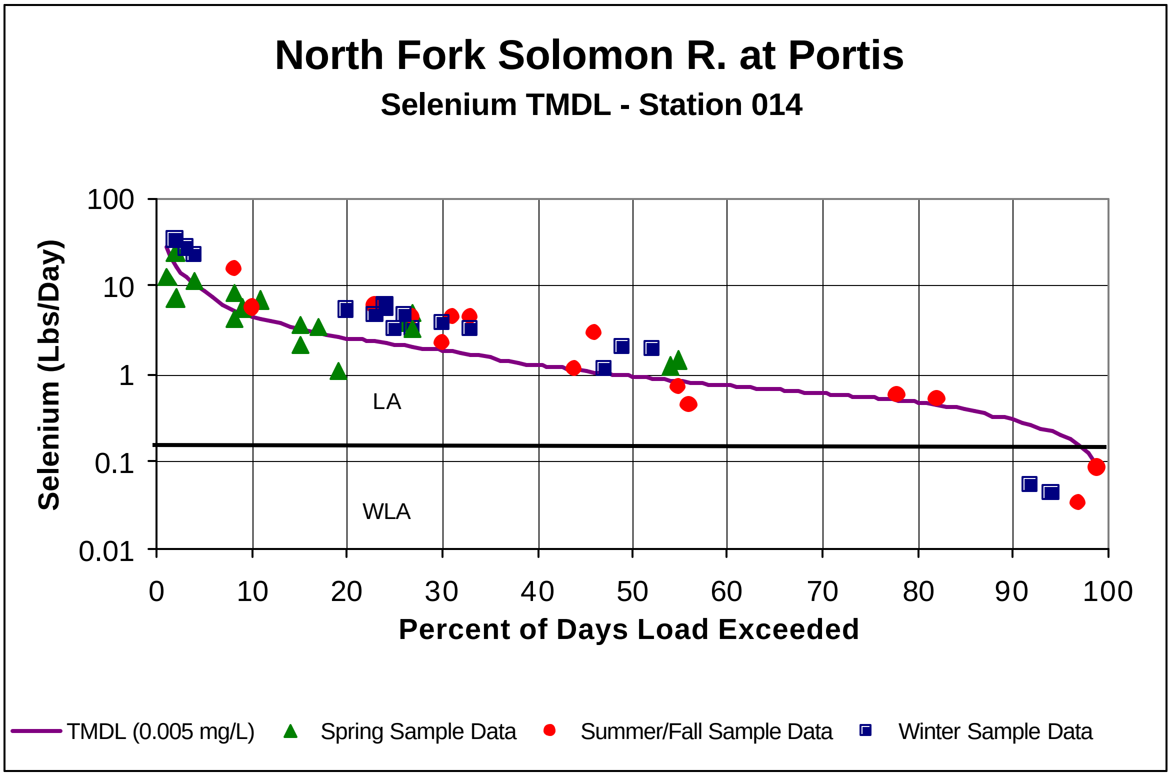

Selenium: WQ Site 668
Twin Creek
Selenium in mg/L
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
3/24/1992
7/21/1992
3/26/1996
5/21/1996
7/23/1996
9/24/1996
11/19/1996
2/22/2000
4/24/2000
4/24/2000
6/27/2000
Sample Date
Aquatic Life Support (0.005 mg/L)
Background (0.012 mg/L)

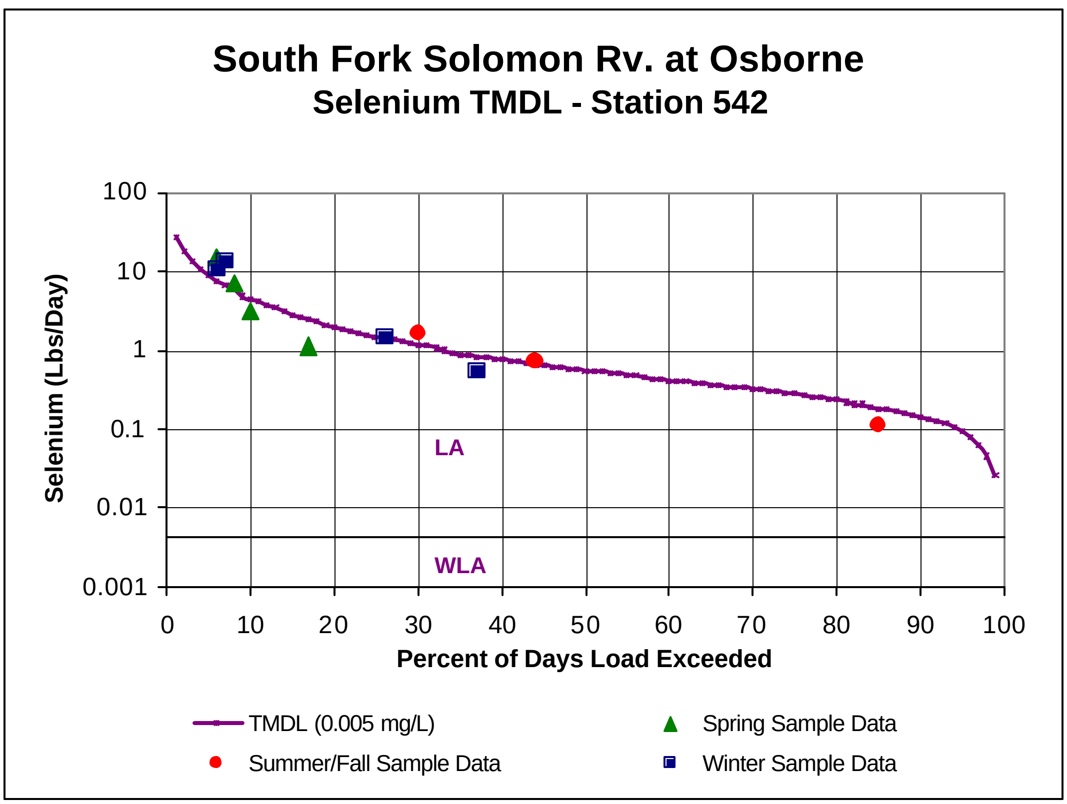

Selenium: WQ Site 669
Carr Creek
Selenium (mg/L)
0.010
0.008
0.006
0.004
0.002
0.000
3/26/1996
5/21/1996
7/23/1996
9/24/1996
11/19/1996
2/22/2000
6/27/2000
6/27/2000
Sample Date
Aquatic Life Support (0.005 mg/L)
Background (0.008 mg/L)

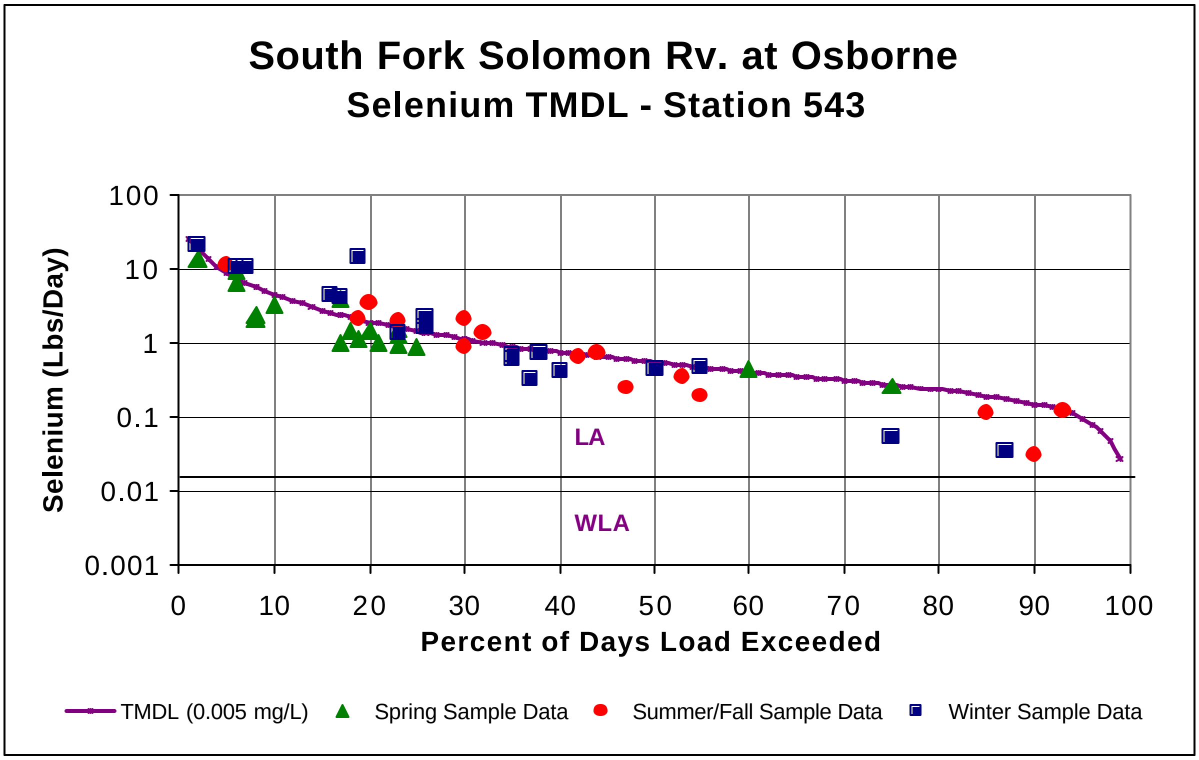

Selenium: WQ Site 670
Beaver Creek
Selenium in mg/L
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1/28/1992
3/24/1992
5/19/1992
7/21/1992
9/29/1992
11/17/1992
3/26/1996
5/21/1996
7/23/1996
9/24/1996
11/19/1996
2/22/2000
6/27/2000
10/24/2000
Sample Date
Chronic Aquatic Life (0.005 mg/L)
Background (0.016 mg/L)


Selenium: WQ Site 721
Deer Creek
Selenium in mg/L
0.020
0.015
0.010
0.005
0.000
5/25/1999
9/21/1999
11/30/1999
2/22/2000
6/27/2000
8/29/2000
10/24/2000
12/20/2000
1/23/2001
3/27/2001
5/22/2001
7/31/2001
9/25/2001
11/27/2001
Sample Date
Dom. Water Supply (0.005 mg/L)
Background (0.009 mg/L)

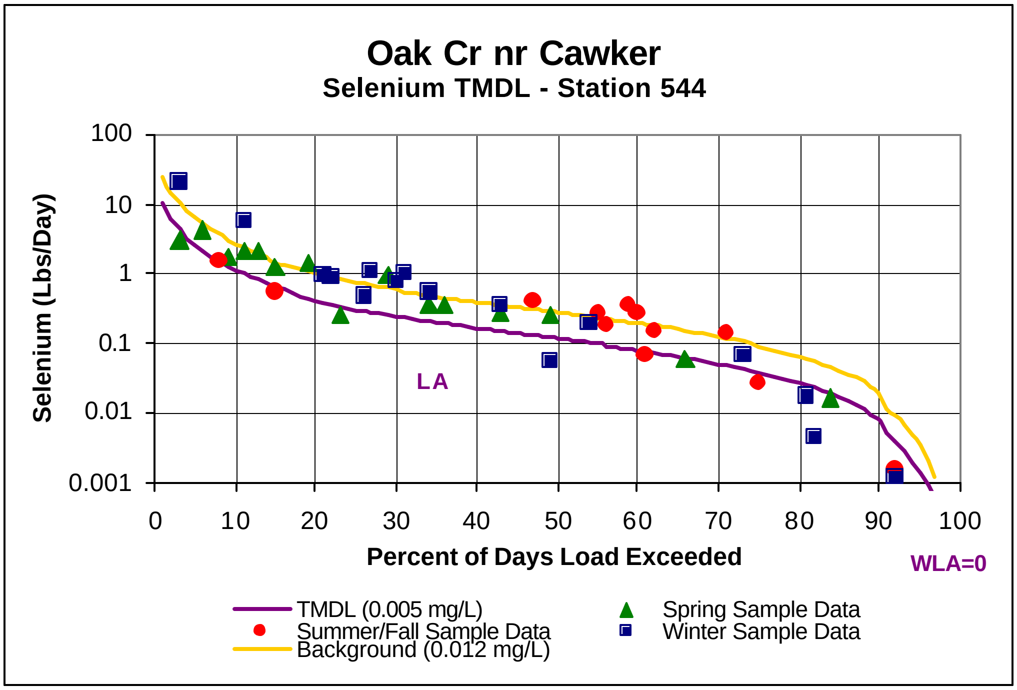
Appendix B - Load Duration Curves



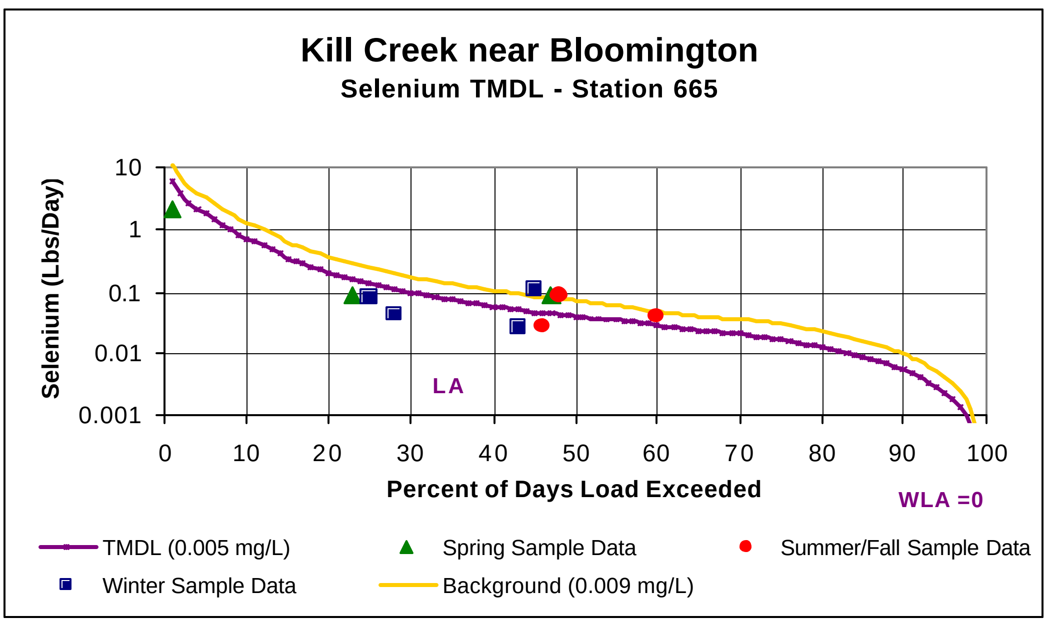




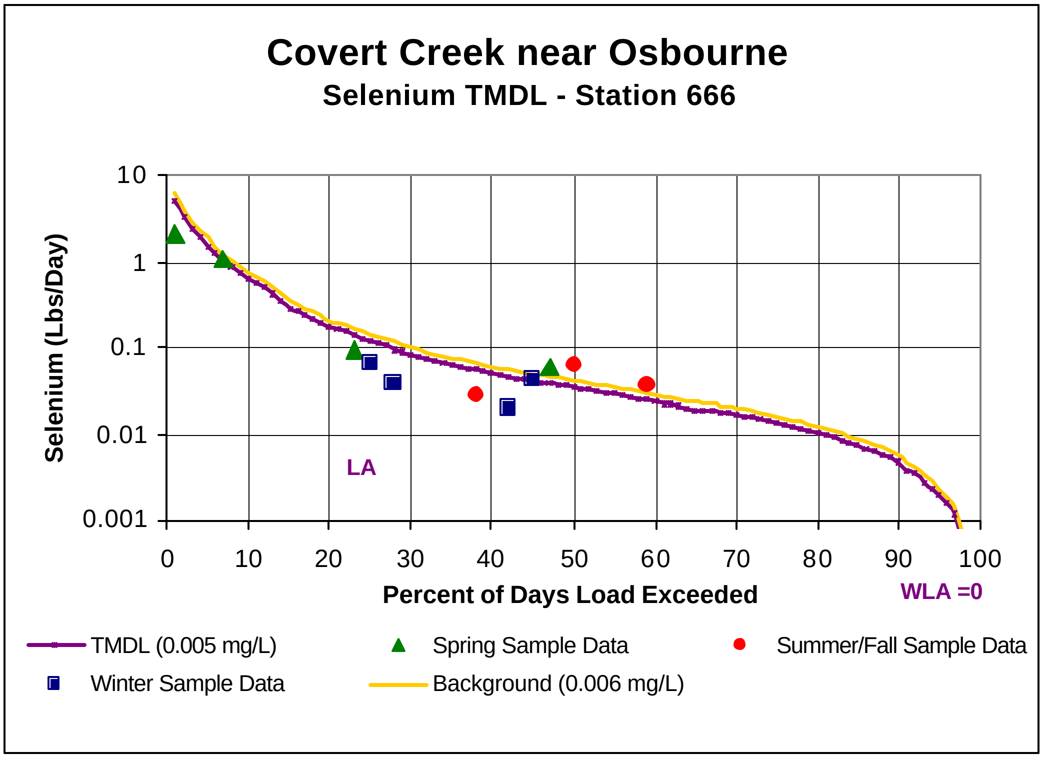
South Fork Solomon Rv. at Osborne
Selenium TMDL - Station 543
Selenium (Lbs/Day)
100
10
1
0.1
0.01
0.001
LA
WLA
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
TMDL (0.005 mg/L)
Spring Sample Data
Summer/Fall Sample Data
Winter Sample Data



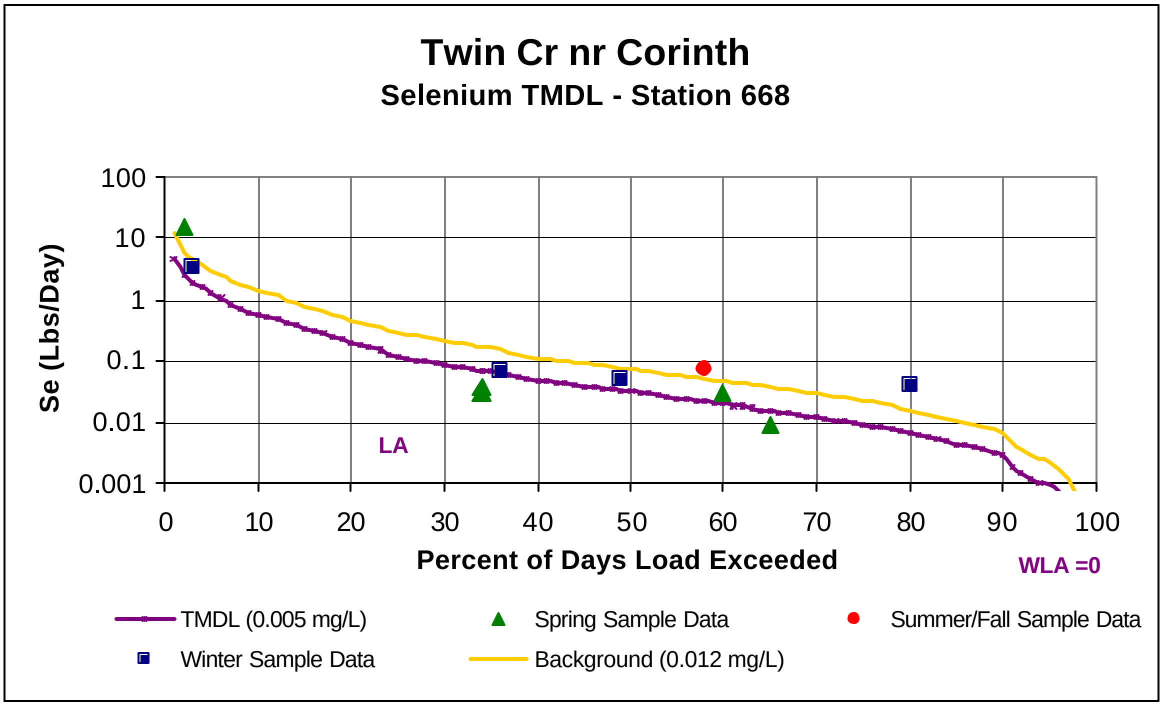
Oak Cr nr Cawker
Selenium TMDL - Station 544
Selenium (Lbs/Day)
100
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
LA
Percent of Days Load Exceeded
WLA=0
TMDL (0.005 mg/L)
Summer/Fall Sample Data
Background (0.012 mg/L)
Spring Sample Data
Winter Sample Data

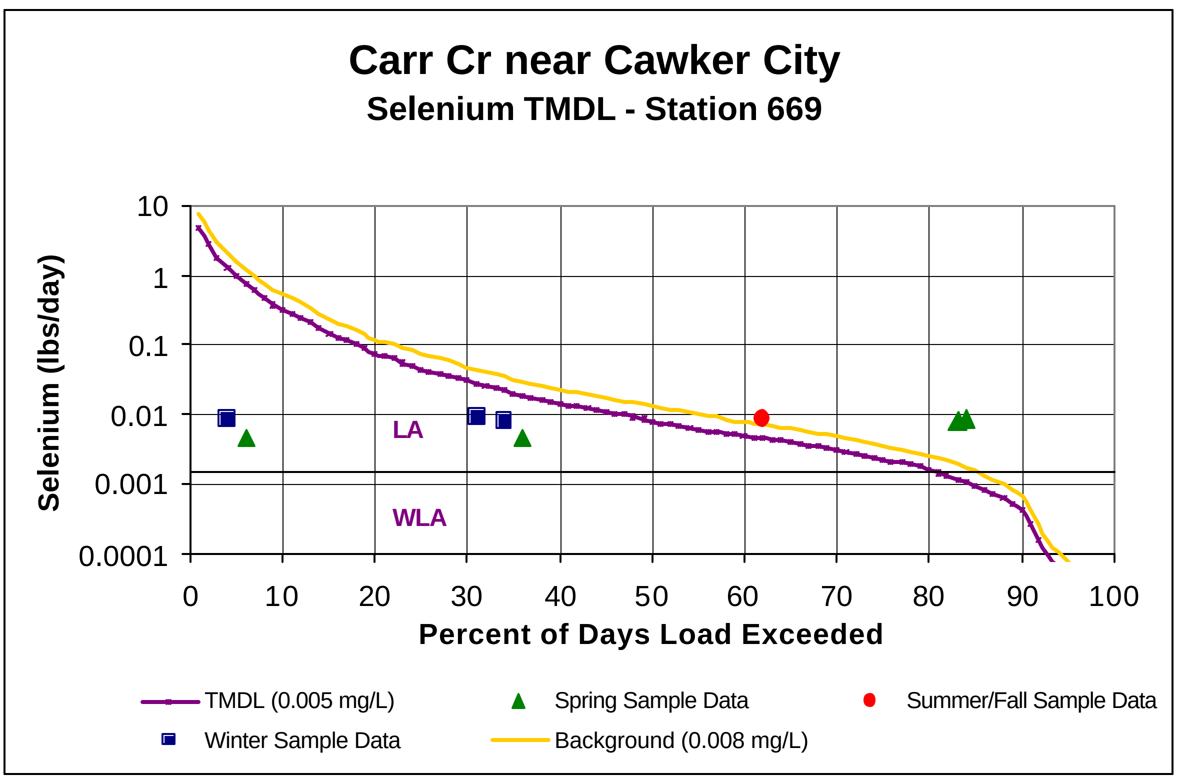


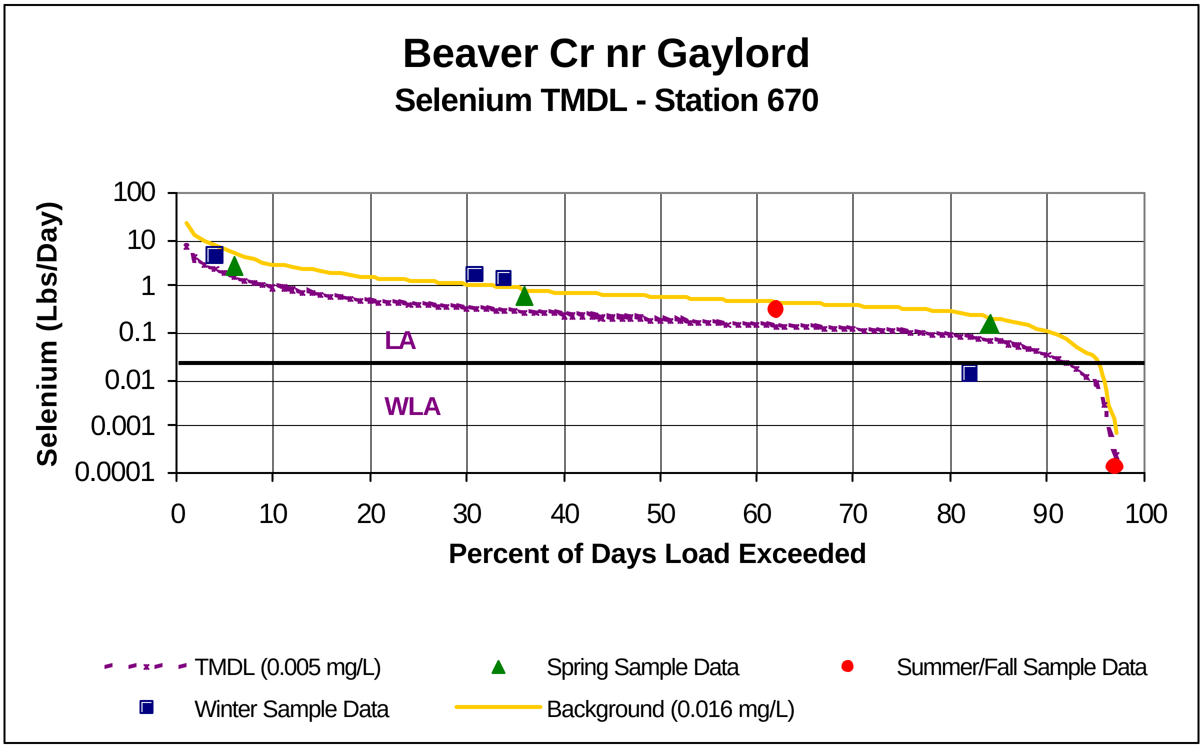
Kill Creek near Bloomington
Selenium TMDL - Station 665
Selenium (Lbs/Day)
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
LA
Percent of Days Load Exceeded
WLA =0
TMDL (0.005 mg/L)
Spring Sample Data
Summer/Fall Sample Data
Winter Sample Data
Background (0.009 mg/L)

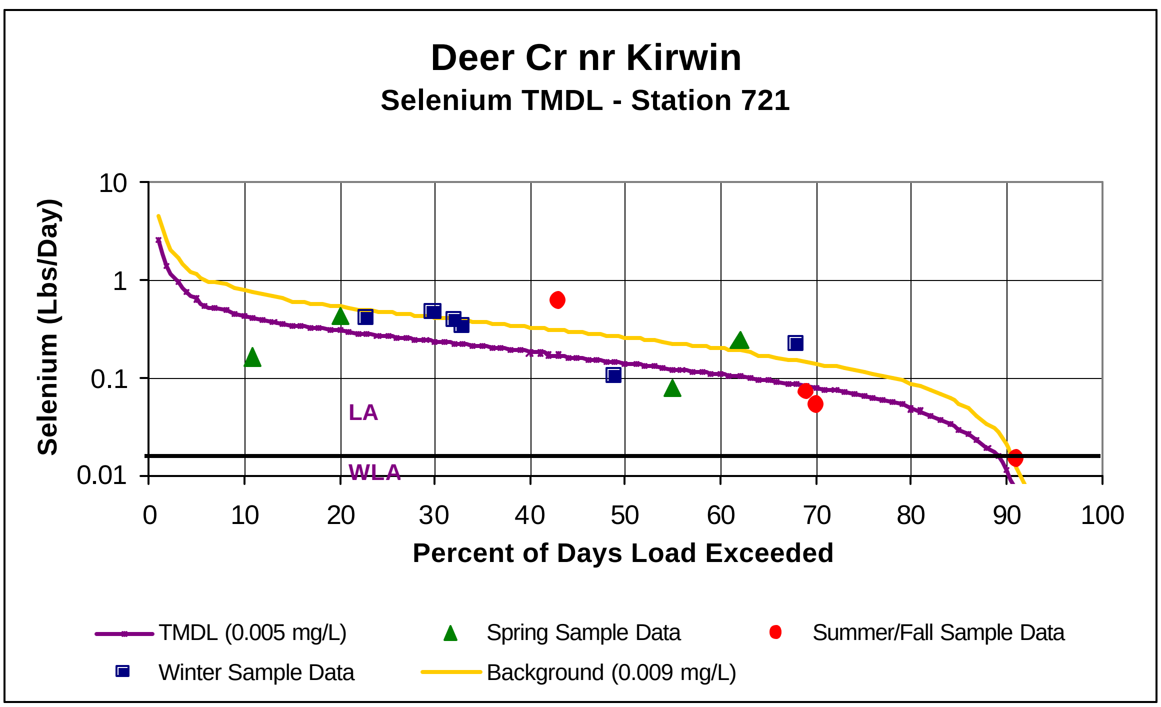


Covert Creek near Osbourne
Selenium TMDL - Station 666
Selenium (Lbs/Day)
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
LA
WLA =0
TMDL (0.005 mg/L)
Spring Sample Data
Summer/Fall Sample Data
Winter Sample Data
Background (0.006 mg/L)


Twin Cr nr Corinth
Selenium TMDL - Station 668
Se (Lbs/Day)
100
10
1
0.1
0.01
0.001
LA
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
WLA =0
TMDL (0.005 mg/L)
Spring Sample Data
Summer/Fall Sample Data
Winter Sample Data
Background (0.012 mg/L)


Carr Cr near Cawker City
Selenium TMDL - Station 669
Selenium (lbs/day)
10
1
0.1
0.01
0.001
0.0001
LA
WLA
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
TMDL (0.005 mg/L)
Spring Sample Data
Summer/Fall Sample Data
Winter Sample Data
Background (0.008 mg/L)


Beaver Cr nr Gaylord
Selenium TMDL - Station 670
Selenium (Lbs/Day)
100
10
1
0.1
0.01
0.001
0.0001
LA
WLA
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
TMDL (0.005 mg/L)
Spring Sample Data
Summer/Fall Sample Data
Winter Sample Data
Background (0.016 mg/L)


Deer Cr nr Kirwin
Selenium TMDL - Station 721
Selenium (Lbs/Day)
10
1
0.1
0.01
LA
WLA
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
TMDL (0.005 mg/L)
Spring Sample Data
Summer/Fall Sample Data
Winter Sample Data
Background (0.009 mg/L)

Appendix C - Wasteload Allocation

Wasteload Allocations for the Waconda Lake Watershed

Station	Kansas Permit Number	Facility Name	Type	Design Flow (MGD)	Se Influent (mg/L)	Se Effluer
14	M-SO21-OO02	KENSINGTON	Three-cell lagoon	0.055	0.0284	0.0284
542	M-SO41-OO01	STOCKTON MWTP	Activated Sludge	0.275	0.0032	0.0032
543	M-SO29-OO02	OSBORNE WWTP	Four-cell Lagoon	0.286	0.0056	0.0056
669	M-SO42-OO01	TIPTON WWTF	Three-cell lagoon	0.023	0.0062	0.0062
670	M-SO38-IO01	SMITH CENTER MWTP	Activated Sludge	0.500	0.0106	0.0106
721	M-SO31-OO01	PHILLIPSBURG MWTP	Activated Sludge In construction	0.350	0.0177	0.0177
721	I-SO31-PO01	TAMKO ROOFING PRODUCTS,INC.	aerated cells	0.027	0.0177	0.0177
Waconda Lake Inflow	M-SO12-OO01	DOWNS MWWTP	Trickling Filter	0.150	0.008	0.008
Waconda Lake Inflow	F-SO08-OO01	CAWKER CITY - WACONDA RES.	Three-cell lagoon	0.085	0.0018	0.0018
			Total	**1.751**		

Approved January 21, 2004